# SCHOOL LIFE

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OFFICE OF EDUCATION

*In this issue*

Education in Science

OCTOBER 1962

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# *Introducing this issue . . .*

ON JUNE 25–29 the Office of Education held a conference for State science supervisors and consultants. It was a working conference, but at all sessions papers were read by distinguished authorities on what is happening and will soon be happening in science and the teaching of science in public schools.

Together, these papers constitute a rich store of ideas and information; and though they will eventually be published in full in an Office of Education report, we are pleased to have permission to summarize or otherwise condense them in this issue, to give wider hearing to the ideas they contain.

In making the compilation, we have had sympathetic cooperation both from the authors and from members of the Office staff responsible for calling and directing the conference—Dr. Dan Hull, director, Instruction, Organization, and Services Branch, and Dr. Ellsworth S. Obourn, science specialist, Secondary Schools Section.

The participants in the conference represented all levels of education, from the elementary school through the university. In their work together they stood for the idea that education in science is a continuous process which should begin early in a child's life.


U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE • ANTHONY J. CELEBREZZE, *Secretary*
OFFICE OF EDUCATION . . . WAYNE O. REED, *Acting Commissioner*
B. HAROLD WILLIAMS, *Acting Director, Office of Information*

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# Brief. . . . . EDUCATION AND GOVERNMENT Reports . . . . . .

## Games for the deaf

President Kennedy will serve as Honorary Chairman of the 10th International Games for the Deaf to be held at Gallaudet College in Washington, D.C., from June 27 to July 3, 1965. About 800 deaf athletes from 33 countries will take part in the games, the first to be held in the United States. Last year, in Helsinki, where the Ninth International Games for the Deaf were held, over a hundred deaf athletes from the United States participated.

Patrons for the 1965 games include Vice President Lyndon B. Johnson, Associate Justice Byron White, Secretary of Health, Education, and Welfare Anthony J. Celebrezze, and Congressman Homer Thornberry.

Copies of a poster announcing the games—the result of a contest among deaf artists—have been sent to clubs and schools for the deaf. Copies of it may be obtained from the chairman of the International Games for the Deaf Committee, Gallaudet College, Washington 2, D.C.

Gallaudet, the world's only college for the deaf, receives partial support from the Department of Health, Education, and Welfare.

## Government guide

The seeming complexities of the Federal Government are concisely and simply charted in the *U.S. Government Organization Manual*, issued each year by the Office of the Federal Registrar, the 1962 edition of which came out in August. In 761 pages the current issue outlines the legislative authorizations and functions of Government agencies; contains 43 organization charts of the Congress, the executive departments, and the larger independent agencies; and lists the names of more than 4,400 key officials. Supplemental sections contain information on Federal agencies which are no longer in existence or whose functions have been transferred to other agencies, quasi-government organizations, and international agencies to which the United States belongs.

The price of a copy is $1.50. It is sold by the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

## Thrifty astronauts

Schoolchildren who enroll this fall in the U.S. Treasury's school savings bond program will become "Junior Astronauts." Each will receive a certificate from the U.S. Treasury which carries the signatures of the seven U.S. astronauts and says "that [name of child], having shown evidence of supporting this Nation's vital Space Program by the purchase of United States Savings Stamps, is now recognized as a Junior Astronaut—pledged to help keep this country strong and free."

The Treasury and schools across the Nation have been partners in the school savings-bond program for over 20 years. Most schools, though they adapt the program to fit their own needs, follow the Treasury's suggestion and hold a Stamp Day each week, on which students can purchase stamps (beginning at 10 cents each). In some schools students handle the details of Stamp Day; in others parents or members of civic groups give a hand.

Through the weekly purchase plan students learn thrift while they support their country; they gain personal security while contributing to national security. Many teachers find the savings-bond program helpful in teaching arithmetic, bookkeeping, social studies, government, and conservation.

Information about the program can be obtained from the Public Information Service, Savings Bond Division, U.S. Treasury Department, Washington 25, D.C. Materials to help promote and operate Stamp Day can be obtained from the savings bond director of each State.

## COSTEP program

Assignments to the Public Health Service's COSTEP Program (Commissioned Officer Student Training and Extern Program) are open each year to medical, dental, engineering, science, nursing, veterinary, pharmacy, and health education students who are interested in careers in the Public Health Service's commissioned

corps and have completed their second or third year of professional education. A COSTEP participant receives a commission equivalent to second lieutenant in the Army and is on active duty for 120 days or less. He works at the National Institutes of Health, the Communicable Disease Center, PHS hospitals and other medical facilities, or in field assignments in public health activities. Most students serve during the summer months, but the program is open throughout the year.

COSTEP has four purposes: To stimulate the interest of promising students in careers in the Public Health Service; to enable students to increase their professional knowledge while gainfully employed; to give students an opportunity to increase their understanding of and interest in the functions of government and independent public health agencies; and to provide the Public Health Service with employees during the vacation months.

About 230 students from 88 professional schools took part last summer in the program. They worked on radiological health surveys and in other public health programs such as those in communicable disease eradication, water pollution control, and dental research.

Information about COSTEP can be obtained from the Public Health Service, Washington 25, D.C.

## War orphans' benefits

Although most of the students receiving help with their education through the War Orphans' Educational Assistance Act (Public Law 634) are in college, eligible students may enroll in business or vocational training programs approved by vocational counselors.

Most students helped by Public Law 634 are between the ages of 18 and 23. They receive as much as $110 a month for as many as 36 months when enrolled in full-time, approved courses; smaller payments for less than full-time courses. To be eligible for help, a student must be the child of a veteran who died as the result of an injury or disability incurred in wartime service or extrahazardous peacetime service. These benefits do not change if the remaining parent remarries or the child is adopted.

In September there were nearly 40,000 students receiving benefits under Public Law 634. During the 6 years the program has been in effect, 4,870 students have prepared or are preparing for teaching, the largest number in any one field.

The Veterans Administration administers the War Orphans Educational Assistance program, and inquiries should be addressed to that agency in Washington 25, D.C.

## Military guidance

Teachers, principals, and counselors will find in the Department of the Army's publication "Military Guidance in Secondary Schools" a guide to preparing young men for military service. A survey of practices now in use in many secondary schools, the publication describes practical ways of incorporating guidance on military service into the guidance and educational programs of a school. It contains suggestions for giving guidance through assembly programs, exhibits on bulletin boards and in display cases, club and classroom activities, consultations, field visits to military installations, and films and other audiovisual devices. It also contains highlights of selective service regulations and military options and suggestions on where to find more information on training offered by the military services.

The publication has been prepared as a public service and as a contribution to national defense. A copy is available on request. Write to the Department, Washington 25, D.C.

## Challenge of change

During American Education Week, November 11–17, the 65 stations of the National Educational Television network and about 90 commercial television stations will show a film, "Challenge of Change: The Case for Counseling," as part of the week-long salute to education. A major statement on the function of educational guidance counseling, the 30-minute film was designed by the Guidance and Counseling Branch of the Office of Education. It was produced by N.E.T. under a grant from the International Business Machines Corporation. The film, a story of a guidance counselor at a high school, takes up such topics as dropouts and career choice.

About 2 weeks after American Education Week another 150 commercial stations will receive copies of the film, and, by the end of the year, 110 prints will be permanently loaned to State education agencies and selected colleges and university film libraries. A study guide accompanies the film for local use. In addition, the film will be available by loan from the education department of IBM, the N.E.T. Film Service at the University of Indiana, and the regional offices of the Office of Education.

The title of the film is in keeping with the theme of American Education Week this year, the 42d annual salute to education—"Education Meets the Challenge of Change" (daily topics are "Our American Heritage," "A Modern Curriculum," "Effective Teaching," "School-Community Partnership," "Lifelong Learning," "International Understanding," and "A Look Ahead.") American Education Week is sponsored by the American Legion, National Congress of Parents and Teachers, National Education Association, and the Office of Education.

# Anthony J. Celebrezze

*The New Secretary of Health, Education, and Welfare*

ON JULY 31, 1962, Anthony J. Celebrezze became the fifth Secretary of Health, Education, and Welfare. His department, the youngest of the departments in the executive branch of the Federal Government, is in its tenth year.

Secretary Celebrezze came to Washington from Cleveland, where he was in his fifth term as mayor. His service to that city was marked by many achievements—among them, improved programs for health, welfare, and recreation, and one of the largest urban renewal programs in the Nation. A feature of the renewal program in which he had special interest was the University Circle Cultural, Educational, and Medical Center.

In 1950 and again in 1952 he was elected to the Ohio Senate, where he served on the Judiciary, Taxation, Veterans Affairs, and Civil Defense Committee and on the Elections and Federal Relations Committee, as well as on the Ohio Senate Highway Study Commission and the Committee on Television Education and Bureau of Code Revision.

He studied at John Carroll University and Ohio Northern University; he received his LL.B. degree from the latter. His wife, a graduate of Western Reserve University School of Education, taught in the Cleveland schools. They have three children.

M. H. Trytten

# *Advances in science—and the need for scientists*

*WHAT ARE THE FORCES behind the ever-accelerating pace of scientific discovery? Dr. Trytten, speaking before the science supervisors at the opening session of their conference, said that intellectual curiosity set the ball rolling and, by itself, drove it far—past the time of such men as Bacon, Newton, Leibnitz, and Galileo. But since the middle of the 19th century, he said, two other forces have reenforced curiosity—the profit motive and, more recently, the self-interest of nations—with the result that scientific development now has a momentum that staggers the imagination. How this momentum affects our need for educated men, Dr. Trytten reduces here to comprehensible terms.*

WE HAVE MADE many attempts to reduce to a quantitative basis the supply-demand equation for scientific and engineering manpower, but none have been satisfactory. Our society is highly permissive, loosely organized, and averse to controls; and practices differ among its many units, to such an extent that they seem almost to defy both analysis and synthesis.

But we have made some progress. The most recent comprehensive study, made by the Bureau of Labor Statistics for the National Science Foundation and entitled "Long-Range Demand for Scientific and Technical Personnel," is useful as a basis for visualizing the trends over the next decade.

The report of this study suggests that we will need an average of 106,000 new workers a year in scientific and engineering fields—85,000 to fill new jobs and 21,000 to replace workers who retire or die. Of the total, 81,000 will be needed in engineering, 25,000 in the sciences.

Where will they come from? In engineering, the report says, about 19,000 of the new workers will probably enter from other fields; the other 62,000 will have to come from the engineering colleges. To compensate for the current fact that 1 in every 7 engineering graduates does not enter the profession, the colleges will have to graduate 70,000 to meet the needs. At present they graduate only 45,000, including both master's and doctor's degrees.

*Dr. Trytten is director, Office of Scientific Personnel, National Academy of Sciences-National Research Council.*

In science the report finds a closer balance between demand and supply. But it does not reflect the substantial demands that will be made in certain accelerating programs in which the national interest is involved and the Federal Government is lending support.

Take the programs of the National Institutes of Health, for example. The report of hearings before a congressional subcommittee on appropriations indicates that by 1970 the annual budget of NIH may reach $3 billion; at that figure, estimates say, some 45,000 additional persons will be needed on the staff. At the doctoral level alone, this will mean 2,800 new employees a year; most of these will be in the biological and medical sciences, yet in 1960 American universities conferred fewer than 1,800 doctor's degrees in these fields.

Or take the National Space and Aeronautics Agency. In 3 or 4 years its annual budget may go up to $5 billion, and conservative estimates say this will mean 1,000 additional staff members at the doctoral level.

In other areas, too, the need for high-level scientists is definitely on the upgrade—in oceanography, as the United States becomes more dependent on the oceans for defense and for raw materials; in the fields of environmental health and the behavioral sciences, as the growing technology complicates both; and in foreign assistance programs, as more talent is exported for educational programs and projects of scientific development.

As our needs increase, what is our rate of training? Enrollments in engineering are declining, both in number and in percentage. Among entering freshmen, engineering enrollments have historically been 9 percent of the total; now they are close to 6 percent. Doctorates in the sciences and engineering are beginning to return, after some lapses in the 1950's, to their historic rate of increase—about 7 percent a year—but they do so at a time when expenditures for research and development are increasing from 30 to 40 percent a year. The imbalance is partly—but only partly—offset by the substantial number of foreign scientists who are here as guests of our universities, chiefly to participate in programs of basic research.

Such studies as the one by the Bureau of Labor Statistics help to illuminate the immediate manpower shortage and the challenge facing us. But they have their

limitations as guides to the future. They are bound by the tangibles of the past and the present—by the facts of employment opportunities and money appropriations, and by trends already established—whereas the growth points of science are unpredictable. Who foresaw that Faraday's discoveries would result in the power industry? That the three-electrode vacuum tube, originally seen as a plaything, would have enormous consequences for communications and research? That the splitting of the atom nucleus was the beginning of a new and scientific age? If anything at all is certain about the future, it is that more ideas will emerge and more discoveries take place, at an ever-accelerating rate, to send us off in new directions of research and application.

But the irrepressible nature of science is not the only factor in the changes bound to come. There are at least two others.

One is the stresses produced when technology and population grow at the same time. The world is consuming its natural resources at a rate that increases geometrically with each passing year, and in the not too distant future the rising curve of demand and the dropping curve of supply will meet. The time of meeting will vary with the commodity and with the technological developments that take place in the meanwhile, and will vary from country to country; but the growing strain on our resources will preoccupy much of the attention of many scientists and technologists. Every possibility for better utilization of our resources—the beneficiation of ores, the technology of miniaturization, and the improvement of alloys and substitute materials—will have to be explored.

A second factor is the growing interrelation between science and technology and the environment, whether human or material. It shows itself, for example, as instrumentation becomes more complex, in the increasingly intimate involvement of man with the machine. As a result, human engineering is becoming a more important field of study—a field that requires not only social scientists who understand technology but scientists and engineers who understand the requirements and limitations

## What can educators do today to provide the manpower for tomorrow?

If anything is certain about the future, Dr. Trytten says, it is that it will bring new scientific developments as earthshaking as any we have yet seen. This is a forecast with deep meaning for educators, and Dr. Trytten has four suggestions for them.

### Give every student a grounding in science.

He should have it for at least four reasons: (1) In a democracy the citizen, through his ballot, is the ultimate determinant of action; he lives in an age when scientific advances bear closely on public affairs, and if he does not understand these developments he is not competent to work out his own opinions about these affairs. (2) The spirit of the age demands it: This is the age of science, and a man's education should prepare him to feel at home in his world. (3) Without an early and thorough grounding in the basic sciences he is likely to be forever shut out from these fields, no matter how much he might eventually desire to enter them. (4) Many fields, such as the behavioral sciences, will become increasingly involved with technological change, and success in those fields will depend on some mastery of science and mathematics.

### Make your high schools large enough.

Records in the National Academy of Sciences-National Research Council show that there is a direct correlation between the size of the high school and the percentage of its graduates who go on to earn doctoral degrees. Apparently a high school graduating fewer than 400 students a year has a hard time providing the environment that starts a student on the road to advanced studies.

### Interest the girls in science.

The small percentages of women in scientific and engineering courses in colleges and graduate schools indicate that we are still neglecting our greatest unused potential. There is no fundamental reason why women cannot accomplish as much in science and technology as men.

### Counsel your students.

In many schools there seems to be a tendency to delay decisions about careers until the students have "had an opportunity to see" the possibilities. This idea has certain appeal, but if in the meanwhile students neglect certain basic prerequisites they will eventually find themselves irrevocably barred from many fields. It is also important that counselors understand the place of science in a liberal education to prepare students to live and work in the modern age.

of the human being. Wherever we look, in fact, we see situations in which the physical sciences and technology relate to the behavioral sciences. Even the designing of a highway has become a tremendously complicated business: it involves questions of land use, urbanization, themes of traffic, social welfare, and group psychology.

The important fact is that the interplay of complex systems, scientific and technological as well as behavioral, presents complexities which call for sophisticated research design, quantitative methods, and adaptation of research to many variable problems. These are complexities which soon will swell the demand for a new and different type of research scientist. As Warren Weaver put it, in a letter to Robert Morison—

"I have a very strong conviction that the 'new form of excellence' required by science over the next half-century will in considerable part consist of techniques for dealing with broader problems, *larger* problems, problems which arise when a moderate number (3 to 100, just as a shot) of small problems are organically interrelated.

"One can start with very obvious and oversimplified examples. The day is past, I would claim, when science can properly treat food supply as an isolated problem, birth rates as another, public health as another. The whole body of servomechanism and feedback theory; many of the techniques of operations research; the emerging knowledge concerning information and communication theory—these are all groping toward the capacity to deal with problems of organized complexity.

"We have been great at producing bits of information, fragments of knowledge. We now need to devote more attention to the fitting together of these bits, to the broader interrelation, and hence to broader utilization.

"* * * We have to humanize science, and give more general meaning and structure—and even value—to it."

## THE CONFEREES . . .

The following are the science consultants and other representatives of State departments of education who attended the Office of Education conference, June 25–29, 1962:

**ALABAMA.** Frances D. Jones, consultant, science.

**ALASKA.** Robert L. Thomas, supervisor, science and mathematics.

**ARIZONA.** Chauncey Coor, director, secondary education.

**ARKANSAS.** Curtis C. Love, supervisor, science.

**CALIFORNIA.** L. Frank Mann, consultant, secondary education.

**COLORADO.** Joseph A. Struthers, consultant, science and mathematics, title III, NDEA.

**CONNECTICUT.** Ralph E. Keirstead, consultant, science education.

**DELAWARE.** Edward J. Hart, supervisor, science.

**DISTRICT OF COLUMBIA.** Eleanor T. Smith, elementary science department, District public schools.

**FLORIDA.** Robert D. Binger, supervisor, science education.

**GEORGIA.** H. Victor Bullock, science consultant.

**HAWAII.** Teruo Massatsugu, supervisor, science.

**IDAHO.** William L. Smallwood, supervisor, title III, NDEA, mathematics and science.

**ILLINOIS.** Archie Woodrome, science consultant.

**INDIANA.** Leo W. Marshall, science supervisor.

**IOWA.** Stanley Kerr, science supervisor.

**KANSAS.** Lewis H. Caldwell, science and mathematics consultant.

**KENTUCKY.** Albert L. Berry and Harry M. Watkins, science supervisors.

**LOUISIANA.** Howard McCollum, supervisor, science.

**MAINE.** Emery S. Dunfee, science supervisor.

**MARYLAND.** Lewin A. Wheat, supervisor, high school science and mathematics.

**MASSACHUSETTS.** John W. Packard, senior supervisor of science.

**MICHIGAN.** Bob R. Sternberg, educational consultant.

**MINNESOTA.** Harold P. Pluimer, science consultant.

**MISSISSIPPI.** R. C. Roberts, supervisor, science.

**MISSOURI.** John B. Leake, science consultant.

**NEBRASKA.** F. K. Alexander, administrator, title III, NDEA.

**NEVADA.** Robert D. Graham, title III, NDEA, science consultant.

**NEW HAMPSHIRE.** Howard I. Wagner, director, science education.

**NEW JERSEY.** Dean M. Laux, consultant in science and mathematics; William D. Guthrie, assistant in science and mathematics.

**NEW MEXICO.** George K. McBane, director, science.

**NEW YORK.** Robert G. MacGregor, science education associate.

**NORTH CAROLINA.** William C. Foil, supervisor, science education.

**NORTH DAKOTA.** K. L. Dooley, consultant in science.

**OHIO.** Stanley Fox, school supervisor, elementary and secondary education.

**OKLAHOMA.** Floyd Thompson, director, instruction.

**OREGON.** Benjamin L. Simmons, director, curriculum and instructional services.

**PENNSYLVANIA.** Albert F. Eiss, science education specialist.

**RHODE ISLAND.** James A. Garvey, supervisor, science.

**SOUTH CAROLINA.** T. C. Bruce, science supervisor.

**SOUTH DAKOTA.** William G. Elliott, deputy superintendent; supervisor, title III, NDEA.

**TENNESSEE.** Donald Wood, supervisor of instruction, science.

**TEXAS.** Severo Gomez, science consultant.

**UTAH.** Richard S. Peterson, supervisor, science.

**VERMONT.** Evan A. Sweetser, consultant, mathematics and science.

**VIRGINIA.** Franklin D. Kizer, supervisor, science.

**WASHINGTON.** James Garner, supervisor, science programs.

**WEST VIRGINIA.** Lee E. Wickline, science specialist.

**WISCONSIN.** James W. Busch, supervisor, science.

**CANAL ZONE.** James H. Pfau, science consultant.

**PUERTO RICO.** Maria A. Ruiz, director, science program.

H. Bentley Glass

# *The biology teacher in a racing world*

*A remarkable review of what has been discovered in biology within the lifetime of people still working among us was Dr. Glass's dramatic introduction to the following statement. The essence of this review has been captured in a box overleaf.*

SOMETHING RADICAL must be done to cope with the ever-widening disparity between what is known and what is taught in the sciences. Our educational system is poorly organized to transmit to the next generation even the core of a body of knowledge which is now increasing at an exponential rate.

Consider the teacher. The teacher of today is the student of yesterday, and the knowledge he passes on in his classroom is largely the knowledge he gained as a student. As he teaches, his skill may increase; but his stock in trade, unless it is changed, will grow more and more outmoded until, after 30 or 40 years of teaching, it is a couple of generations behind the times. In the secondary school the problem is aggravated if the teacher comes from a college or university where the professors of science teach what *they* were taught.

Nor do we escape the dilemma by turning to our textbooks. Today's biology textbooks, for example, represent for the most part the knowledge of 30 years ago. The people who write them have the same problem as the rest of their university colleagues: Unless they remain avid learners and have the rare skill of critical evaluation and synthesis, their knowledge becomes obsolescent at a horrifyingly rapid rate.

Obviously the first answer to the problem is to keep the curriculum up to date. Curriculum studies are now progressing in the United States in physics, mathematics, biology, chemistry, and geology, with support from the Federal Government through the National Science Foundation. Large and expert groups of scientists and teachers have been enlisted to prepare textbooks, develop laboratory programs, and work out innovations in teaching methods; for the first time in American history, curriculum studies are producing something more tangible than recommendations and outlines.

The curriculum study on biological sciences tried out its preliminary materials in 118 schools in 1960–61, and then thoroughly revised them for trials in 350 schools in 1961–62. By September 1963 the tested textbooks and laboratory guides, together with teachers' guides, will be available for use on a national scale. Of course, this is only the beginning; such is the tempo of scientific advance that even as the new books are issued they will need revision.

The teachers who will use these programs, however, are not at present trained in the basic science they need to handle them well. Many of those trained to teach biology, for example, do not know enough chemistry, particularly not enough biochemistry, to deal with modern biology. They need reeducation, on a systematic and continuing basis. Fortunately, there is a general awakening to the science teacher's need for this kind of education, thanks largely to the summer science institutes begun by the National Science Foundation in the 1950's. Already these institutes have done much to improve the level of science teaching in hundreds of our secondary schools; and now, using the new materials from the curriculum studies, they will have an even greater effect on a broader scale, and a new kind of science teaching can be expected to evolve rapidly.

Improvement in the secondary schools is not enough, however. Already it is evident that science cannot be taught well in the secondary schools unless it is also taught well at the lower levels; and a thoroughgoing revision of the science teaching program is therefore in order for both elementary schools and junior high schools—and will be undertaken. Can we expect less of the universities? If the secondary schools teach a modern biology, can the colleges and universities prepare teachers and train scientists by teaching an antiquated biology? The large-scale revision indicated for institutions of higher learning seems even more urgently needed in the light of the very real possibility that in a decade or two every practicing scientist and every science

*Dr. Glass is professor, department of biology, John Hopkins University. For the past 4 years he has been chairman of the Biological Sciences Curriculum Study of the American Institute of Biological Sciences—a study undertaken to bring up to date and otherwise improve the teaching of biology in secondary schools.*

teacher will be expected, no, *required*, to spend 1 year in 3 being reeducated.

In a scientific society aspiring to democracy, the responsibility of us who teach biology and the other sciences is enormous. Our task is not simply to teach a lot of scientific facts, or even the important concepts and principles—that the earth is round and not flat, that the atom has energy in it, that genes control an organism's path of development. All those are important; but it is far more important that the learner comprehend the true nature of the process by which knowledge about matter and energy increases, and by which man gains new understanding of life and its place in the universe. Here lies our power as teachers—that we can help him comprehend. We can be pioneers, reorganizing and reinvigorating the teaching of the sciences and giving it new direction.

What goes on within a living cell provides us with an analogy of the teacher's work. Each active chemical system in a cell consists of substrate, enzyme, coenzyme, and an energy-rich molecule called adenosine triphosphate. The teacher plays the part of the enzyme, which com-

## Revolution in biology—an example of the "exponential

SCIENTIFIC KNOWLEDGE is "increasing exponentially" in this century, Dr. Glass says. In other words, if in 1930 we knew 4 times more than we did in 1900, then in 1960 we know 16 times more and by the year 2000 are likely to know 100 times more. The accelerating increase shows itself also in the number of scientists: It has been estimated that over 90 percent of all scientists who have ever lived are alive and working today; that the number of them, said to be 1 million now, may increase to 20 million or even 30 million by the end of the century. Here Dr. Glass draws upon his own field, biology, to make vivid his phrase "the exponential increase of scientific knowledge":

### In 1900

The biology textbook of 1900 had nothing in it about genetics, for mendelian heredity was not rediscovered until that year . . . nothing about biochemistry in its modern sense, for it was only 3 years old . . . nothing about the nature of enzymes . . . nothing about hormones, immunology, the blood groups, or specific vitamins . . .

. . . very little about antibodies, for knowledge of their existence was only 10 years old . . . barely a hint about viruses, and *that* only about plant viruses . . . almost nothing about what affects the development of an embryo . . . nothing about Pavlov's studies into conditioned reflex behavior.

### Between 1900 and 1930

Great discoveries filled the gaps noted above: The chromosome theory of heredity was postulated and proved . . . the complexities of multifactorial inheritance were unravelled and applied in the breeding of vigorous hybrids, such as hybrid corn . . . the first vitamins were discovered, and the deficiency diseases they correct were determined . . .

. . . animal and bacterial viruses were discovered . . . findings about antigens and antibodies resulted in the whole new field of immunology . . . mutations in genes were found to result from high-energy radiations . . . the first new species was created by the hand of man . . .

### Between 1930 and 1960

Biology made almost incredible advances: Discovery that mutations can be induced by chemical agents, and that certain agents induce characteristic types of mutations . . . that the material basic to heredity and reproduction is not protein after all, but deoxyribose nucleic acid (DNA) . . .

. . . development of a theory about the structure of the DNA molecule and its method of replication that led to the discovery of how DNA passes information to RNA (ribose nucleic acid) and how the latter in turn specifies the amino acid structure of protein or polypeptide chains . . . the synthesizing, from a bit of native DNA, of an abundance of new DNA, which is the first step toward the artificial creation of genes . . .

. . . the "cracking of the genetic code," that is, the finding of the composition of the 21 nucleotide triplets in RNA which convey genetic information to the protein-synthesizing centers of the cell . . . the "fingerprinting" of the protein molecule of insulin and, subsequently, of several other protein molecules, by identifying their amino acids and mapping the entire sequence of them within the molecule . . . and other discoveries that have carried the science of evolution far beyond the theoretical and observational Darwinism of the early 1920's to a strong experimental science that permeates all of biology . . .

. . . discovery that the single "harmful" gene which produces sickle hemoglobin is maintained in the populations of central Africa because it confers protection against tertian malaria . . . the equally exciting discovery that the sickle hemoglobin differs from normal hemoglobin only in that it contains in its entire molecule a single amino acid residue not present in the other . . .

. . . discovery of still more vitamins, such as folic acid, vitamin B–12, pyridoxine, and nicotinamide, and of more facts about the importance of vitamins

bines with the substrate, changes it, and then releases it—and, in the process, is itself renewed. So the good teacher combines his mind for a time with the minds of his students, and then cuts them loose, after an engagement which has changed both the students and himself.

The meaning of the analogy is this—that the good teacher of science never "teaches at" his students; rather, he learns with them. And where can he do this better than in the laboratory or the field? There, aided by the coenzyme of modern teaching materials and by plenty of high energy, he plays his part in making the precious product—the enlightened mind—develop. Of course the cell also instructs us—as we examine the marvelous devices of the mitochondria, the chloroplasts, and the ribosomes—that organization to a refined degree is also requisite.

In laboratory and field, however, the teacher becomes more than enzyme. These are the places where scientists work; there the growing student can become, at least for a day, a scientist himself. And the teacher, transcending the art of the enzyme, can become a gene. For what but a gene can replicate itself?

## increase" in scientific knowledge

in the chemical machinery of life . . . discovery of the nature of adenosine triphosphate and its remarkable functions in human metabolism . . . the first successful attempts to synthesize hormones . . . studies into the physiological action of cortisone, ACTH, and the sex hormones . . .

. . . discovery of such antibiotics as penicillin, streptomycin, and aureomycin, and of the antibacterial powers of sulfanilamide . . . development of DDT and many other insecticides . . . introduction of the electron microscope and the phase microscope, and the resurgence of morphological studies of cell structure and processes . . .

. . . studies that raise hopes of tying together the biochemistry and the ultrastructure of the cell . . . particularly, studies on the mitochondria which have told us much about respiration and location of Krebs' citric acid cycle, a discovery of the 1930's . . . and studies on the chloroplasts which illuminate the basis of photosynthesis and place the steps in $CO_2$ fixation and in photosynthetic phosphorylation, two processes discovered in the 1950's . . .

. . . use of electron micrography to determine the structure of viruses and to analyze the single large DNA molecule . . . and other developments that shed light on the borderland between living organisms and the inorganic world . . .

. . . discovery that bacteria have sex, chromosomes, and genes, and the consequent opening of the whole new field of bacterial genetics . . . discovery, in studies with the pink bread mold, that each individual mutation which prevents growth does so by blocking a single specific step in metabolism . . .

. . . much more besides . . . vast and fundamental advances in ecology and in the study of animal behavior . . . in the study of populations and communities and the management of them . . . and in knowledge about their biology, in every aspect of it, down to the biochemistry and biophysics of their ultimate atoms and molecules . . .

. . . and, along with it all, a great increase in our understanding of race and of evolutionary problems that may enable us to act more wisely in the future.

### Between now and 2000?

What the rest of the century will bring, we can only guess. But the past informs our guesses . . .

. . . a new era in medicine will dawn . . . the marriage of biochemistry and genetics will continue to bear fruit . . . and we will apply to man, as we have applied in the past, our new and growing knowledge about the metabolism of mold and bacterium . . .

. . . we will learn, step by step, how to correct the inborn errors of our metabolism, the faults of our genes . . . will find what metabolic step is blocked in each disorder . . . what product we must supply to compensate for it . . . and what substrates are not utilized because of the blocked step and therefore accumulate in the body with harmful effects . . . how these substrates can be eliminated . . .

. . . we will probably learn not only how to extend man's life but how to maintain its vigor into old age . . .

. . . we may learn how to create simple forms of living organisms, something as complex, perhaps, as a virus . . . may even discover how to cultivate the reproductive cells of man and animals, to produce normal embryos, and to raise them to term, either in artificial cultures or in foster mothers . . . and, in the process, may find how to modify defective genes or replace them with sound ones . . .

. . . we are almost certain to solve the problems of photosynthesis and thereby assure ourselves of an inexhaustible supply of food . . . may even find ways to impart good flavor to it . . .

. . . we will learn how to accelerate our own evolution, but who knows what direction we will choose? . . . infectious diseases will probably be banished forever, but enough space for a population uncontrollably growing seems out of question on this planet . . . and happiness will not flower inevitably from the burgeoning of science.

PAUL KLINGE

# *Resources for improving instruction in biology*

*"Evolution not revolution is taking place in biology teaching," Mr. Klinge said in the introduction to his speech. He went on to explain that "revolution implies sudden, drastic, and traumatic change which destroys old values and ideas. Evolution means change, but change which may be variable in rate, change with deep roots in history. It is easy to trace the history of many of the changes which are now occurring in the teaching of biology. Natural selection will act to eliminate practices that do not prove useful."*

MANY RESOURCES are available to us for improving instruction in biology. These include improved teacher training, curriculum studies, reading material, supply company aids, audiovisual aids, television, facilities and equipment, career pamphlets, and the work of professional societies.

## Improved teacher training

The most important resource we have for improving instruction in biology is improved teacher training. Certification requirements for biology teachers are beginning to reflect improved training. Requirements are now emphasizing the biology teacher's need for general courses in the humanities as an integral part of his education. Biology is more than a technical subject, and biology teachers need more than technical training. Certification requirements are also emphasizing the need of biology teachers for training in other sciences. Biology has become an integral and important part of the total science picture. A biology teacher who does not know something of chemistry, physics, mathematics, and geology seriously jeopardizes his students' understanding of biology. If we continue to insist that other sciences be included in the biology teacher's training, the day of the biology teacher with a physical education major or minor will be on the way out.[1]

Teacher training should not end with a simple 4-year course for certification, however. We should emphasize the inservice training of teachers. The National Science Foundation (NSF) has a program of inservice training for science teachers that is having tremendous effects. Some colleges and universities have programs of their own, some antedating NSF's. The fifth-year program of some universities is an effort to meet the need for good subject-matter training for teachers. Some colleges and universities invite high school teachers to attend seminars, discussions, and conferences on science. The visiting scientists program is another effort to improve teaching. NSF has sponsored some of these visits by recognized scientists to high schools, though the program originated in professional societies. The program of visits by high school teachers and students to college campuses and institutions for instructive discussion by the staff is another boost for science teaching.

## The Biological Sciences Curriculum Study

The Biological Sciences Curriculum Study (BSCS) was established in 1959 by the American Institute of Biological Sciences to improve high-school biology. It is being conducted at the University of Colorado under the direction of Arnold Grobman. It is preparing textbooks, laboratory materials, books for the gifted student, monographs, teacher aids, and films. Its three textbooks will be published soon. On the assumption that there are many ways to teach biology, these texts will not reflect or duplicate the emphasis of traditional textbooks. The laboratory material of the study is unique. It encourages the student to use the laboratory as a place to draw, copy, and dissect, and requires him to observe, experiment, and come up with answers not found in the textbook.

An original idea in BSCS's material is the so-called "blocks," [2] laboratory exercises centered on one specific topic which takes the student about 6 weeks to complete. Blocks are not necessarily related to classwork. The old assumption that laboratory work must correlate and integrate completely with classwork appears logical, but there is little objective evidence that such correlation is necessary. Biology has a time problem: Organisms have a definite period of growth. The biologist must wait until the growth is at the point necessary to his experiment.

*Mr. Klinge is coordinator for school science and assistant professor of education at Indiana University and editor of the* American Biology Teacher.

[1] Paul De H. Hurd, "The Education of Secondary School Biology Teachers," *American Biology Teacher*, May 1962, pp. 327–331.

[2] Addison E. Lee, "The Experimental Approach in Teaching Biology," *American Biology Teacher*, November 1961, pp. 409–435.

Growth cannot be hurried up to fit a 50- or 60-minute laboratory period. Blocks will allow for growth. I predict that the blocks will become one of the most important features of the BSCS program.

BSCS's two volumes for gifted students are efforts to inspire the student interested in advanced project work. They suggest projects in detail but are not recipes. Suggestions are simply "teasers" for the student.

BSCS's series of monographs, many of which will be in paperback editions, is now in press. These monographs should be on the biology shelf of every library.

Detailed teacher aids and guides accompany all of BSCS's material. One volume just off the press will probably be one of the best resources in the entire country for improving instruction insofar as methods and materials, facilities, and equipment, are concerned. I recommend it for your close inspection.

BSCS activities include the production of short films, mostly to illustrate techniques. They do not duplicate anything on the market.

## Other curriculum aids

Another curriculum aid is the volume "Modern High School Biology," by the Science Manpower Project of Columbia University.[2] It antedates many BSCS materials and predicts some things which the BSCS has taken as major parts of its program.

States and cities have also produced curriculum studies—notably the State of New York, New York City, Chicago, San Diego, Los Angeles, and Indianapolis. These are detailed enough to be good sources of information and to serve as models for other school systems trying to improve biology teaching.

## Reading material

It is impossible to list all of the magazines, journals, paperback books, and text materials which have come out in the last 5 years of interest to the biology teacher. I have singled out a few I consider particularly helpful:

The *Scientific American* is a "must" item for all science teachers. The magazine has no peer in the range, scope, and quality of its articles. From it the teacher can learn how a skilled science writer or scientist translates intricate facts into a palatable form for a variety of readers.

The *American Biology Teacher* and the *Science Teacher* are also indispensable. Many of the articles in the latter, though not on biology, contain enough general information to warrant careful reading.

Among recent paperback books are reprints of the classics in biology as well as brand-new volumes. Some of these are specifically for biology students, including Prentice-Hall's series "Foundations of Modern Biology" and Doubleday's "Natural History Library."

Some of the text materials being prepared for college use have been radically revised from previous material and employ methods that are new but pertinent to high school biology classes. They are particularly good for the high school teacher wanting more detail on certain topics than the regular high school text provides. I am impressed with quite a few of these new books, but it would be out of place to list all of them here. I would, however, like to recommend the new text by Garrett Hardin; the classic by Simpson, Pittindrigh, and Tiffany; the orthodox text by Johnson, Laubengayer, and Dellanny; and the text by Weisz which emphasizes biochemistry. These texts can be important aids for the teacher because they translate many complex ideas for him which he can in turn translate for his own class.

Among new textbooks are some for college methods courses. The old Miller and Blaydes text, for instance, has been revised. The new sourcebook by Morholt, Brandwein, and Joseph is one of the finest sources of ideas, techniques, and methods every teacher needs.

## Aids from supply companies

For many years the General Biological Supply Co. has produced a series of invaluable aids for biology teachers called the Turtox Leaflets. Ward's Scientific Establishment now publishes similar materials, such as its latest publication "Culture Leaflets," an effort to aid biology teachers objectively. The Welch Scientific Company has for some time been publishing the "Welch Biology and General Science Digest." All of these are aids to the biology teacher and are good examples of how scientific suppliers can assist the science teacher.

## Audiovisual aids

The lists of audiovisual aids available for science teaching fills several catalogs. One type of audiovisual aid for the biology teacher is recordings, some of which include birdcalls and other animal sounds. Another type of recording carries a rapid review of many biological principles to be played over and over again until the student learns these principles (I am not enthusiastic about these recordings). There are also series of large color photographs suitable for framing or bulletin board use available from Filmscope Inc., Box 397, Sierra Madre, Calif.

## Facilities and equipment

There are several good references to help school people know what equipment the laboratory requires and how to

[2] Dorothy Stone, "Modern High School Biology," Bureau of Publications, Teachers College, Columbia University, New York, 1959, 96 pp.

choose it. The *Purchase Guide for Programs in Science, Mathematics, and Modern Foreign Languages* lists items and equipment necessary for biology instruction which can be purchased with National Defense Education Act funds.[4] Another reference is BSCS's list of facilities, which the teacher should study closely, regardless of whether he is using BSCS program material.[5] Other organizations have also gotten together lists of equipment and facilities useful to anyone preparing preliminary drafts of new buildings. These include the Midwest Research Associates of Kansas City, the National Science Foundation, and the Educational Facilities Laboratories.

## Career pamphlets

An essential feature of good biology teaching is to inform students what careers are available in the various disciplines of biology. "Career Opportunities in Biology," published by Row-Peterson, is still the standard work. Lists of pamphlets on separate fields are extensive; practically all professional science teaching journals carry bibliographies of these. Some universities are preparing their own publications, and professional societies are preparing pamphlets on specific careers. The new publication, "Microbiology in Your Future," by the American Society of Microbiology, is an outstanding example.

## Professional societies

There is no doubt in my mind that a biology teacher's membership in professional societies will assure his reading the journals the societies issue. The teacher's attendance at meetings of societies, as well as his reading of their publications, is one of the best methods by which the teacher can improve his teaching. I believe it is the responsibility of every science supervisor not only to encourage his teachers to join professional societies, but to make membership a prerequisite for advancement and professional recognition.

[4] Counsel of Chief State School Officers, Educational Facilities Laboratories, Inc., and others. Ginn & Co., Boston, 1959.

[5] Barthelmy, Dawson, and Lee, "Equipment and Techniques for the Biology Teaching Laboratory." BSCS, University of Colorado, Boulder, 1962, 211 pp.

## What's yet to be done to improve biology instruction

Looking into the next 10 years, Mr. Klinge sees a number of things that will have to be done to improve instruction in biology. Among those he considers most important are the following:

### 1. Industry must support biology teaching.

While industry has effectively supported physics, chemistry, and mathematics programs, its support of biology teaching has been conspicuously small. Such support as industry has given, I believe, has been for agricultural programs. Agriculture is important but as a course it is taken by only a few students; practically *all* students take biology. We should explore ways of getting industry to support biology. The pharmaceutical industry, for instance, should support programs in biology similar to the chemistry and physics programs the chemistry and physical science industries support.

### 2. We must revise curriculums for teacher education.

We must revise them to reflect the changing emphases in biology and, more importantly, in the training of biology teachers. The traditional lockstep of courses is not adequate. Simply shuffling courses around to improve certification or to change the pattern of training within an institution is not enough. Colleges must really try to revise their whole biological science sequence for the training of biology teachers.

### 3. Societies must form more local chapters.

Unlike the American Chemical Society, biological professional societies seem to have few local chapters. If the success of local chapters of the ACS is an indication of what they can do to improve instruction, then the biological professional societies must form more local chapters.

### 4. Foundations must give more support.

At present, foundations do not give the amount of support the number of biology students warrants. It is true that many grants go under headings which may be biology, though they do not sound like it. The announced purpose of such projects seems to place biology in a second-rate position.

### 5. We must judiciously edit our textbooks.

When a new biological fact comes to light, we cannot assume that all we have to do is add a chapter to the biology text. We must integrate new information with old, cull out what is no longer true, and avoid the encyclopedic method used in many traditional textbooks. In short, we must edit our courses so that the most essential things can be taught in the time we have.

We must apply this process to all programs in science education, from the kindergarten through grade 12. If more science is taught in the elementary school, the high school biology course will have a framework to build on that it has not had in past years. In the future, therefore, we will give considerable and necessary attention to the K–12 sequence, so that biological concepts will be presented initially in the lower grades and then be built on in the terminal courses in high school.

ROBERT L. SILBER

# *Resources for improving instruction in chemistry*

*The article below is an excerpt from Mr. Silber's address to the conference, limited to his description of the resources now available to schools for improving instruction in chemistry. Before he got into this description, Mr. Silber pointed out that the well-trained teacher is our best resource for improving education and that our task is to provide him with the best possible assistance.*

RESOURCES for improving instruction in chemistry include new study courses, reading material, science kits, programed instruction, and television.

## Course content studies

Three new study courses in high school chemistry are the Chemical Bond Approach (CBA Study), the Chemical Education Materials Study (CHEM Study), and the Encyclopaedia Britannica's film series on modern chemistry.

The CBA Study project began in 1959 and has been conducted at Earlham College under the direction of L. E. Strong. It has prepared a text and laboratory materials for an introductory chemistry course and is preparing a comprehensive teacher's guide.

The director of CBA, in describing the project, says that "a very basic characteristic of the CBA chemistry course is that chemistry is inherently fascinating and that this fascination can be seen by students early in their exposure to the subject. The CBA group is convinced that chemistry is more than facts possessed by chemists, but rather a subject as practiced in a powerful process for uncovering and extending natural phenomena. The power resides in the combination of ideas and facts or of concepts and experiments. As the student finds himself able to participate in the process, he also finds fascination." [1]

The CBA study is based on the organization of chemistry instruction around a central theme: Chemical bonds; or, to put it in another way, chemicals possess characteristic structures. The course is so organized as to help the student reach an understanding of the interaction of conceptual schemes and observation. If the data he collects are meaningful and useful to him when he studies the meaning of basic phenomena, the student's laboratory work is successful. CBA presents laboratory exercises as open-end experiments. When the student receives a problem he tries to decide what information he needs to solve it. In many cases the solution he reaches or the difficulties he encounters suggest other paths of exploration. The course encourages him to explore these paths if they are intriguing to him.

Certain other central ideas woven into the course support CBA's central theme. One of these is the use of mental models. Chapter one of the course presents the first mental model by comparing some of chemistry's unseen mechanism to the contents of a sealed box. CBA's director recognizes "that chemical reactions raise questions which cannot be answered solely by experiment and that . . . chemicals are to be regarded as black boxes whose interworkings are perceived through the eye of the mind. The general scientific strategy is taken up more directly as the student is led into the development of an atomic and molecular model out of assumptions and logic. Since the atomic models do not deal with all aspects of matter, a second model is added which deals with the kinetic molecular theory. To this latter discussion, a model is constructed which tends to become disorganized and thus to mimic the tendency of gases, liquids, and solids to expand. The two models, one for structure and the other for disorder, are then applied together for a systematic discussion of several reactions." [2]

The course is built on the theory that if a student has a real grasp of concepts, theories, and principles with appropriate facts to accompany them, he obtains a much better conception of the feeling of chemistry and what it can do than he does from the learning of many isolated facts. Challenging experiments undergird the course presentation.

The course is in its third year of revision. About 200 teachers are using it with 10,000 students; 82 teachers in 77 high schools are evaluating it. Educational Testing Service is assisting the project staff in the preparation of tests. Students take achievement tests at the beginning and at the end of the year so that their progress may be

*Mr. Silber is educational secretary of the American Chemical Society.*

[1] *CBA Newsletter*, No. 9, February 1961.

[2] Ibid.

plotted. The text, together with a laboratory manual and teacher's guide, will be available in final form in the fall of 1963.

The CBA project is also trying to determine the relative achievements of students who have taken the Physical Science Study Committee course (PSSC) (see Mr. Lefler's article, p. 18) and the CBA course and those who have not taken the PSSC course but have taken CBA's. It is also following up on CBA graduates to determine their success in college.

The course has gained international recognition. CBA institutes for teachers have been held in Chile, Pakistan, and the Philippines. Members of the project have attended a conference in Dublin sponsored by the Organization for Economic and Cultural Development. Foreign chemists have visited the project at summer institutes.

The CHEM study project is an outgrowth of the work of a committee set up in 1959 by the American Chemical Society to study the purposes and content of high school chemistry courses with a view to producing a drastically improved course.

According to CHEM, "the general objectives of the study will be to develop new teaching materials for the high school chemistry course, including a textbook, laboratory experiments, films, and supplementary reading materials. The more specific objectives will be to diminish the current separation between scientists and teachers in the undertaking of science, to stimulate and prepare those high school students whose purpose it is to continue the study of chemistry courses that are geared to keep pace with advancing scientific frontiers, and thereby improve their teaching methods, and to further in those students who will not continue the study of chemistry in high school an understanding of the importance of science in current and future human activities.

"It was decided in the very beginning to have a high school chemistry course strongly based in experiment and to have the text thoroughly dependent upon and integrated into the laboratory experiments, with the supplemental use of integrated films where they may be helpful. Another basic tenet was to make the course applicable to the average student who takes high school chemistry rather than to the gifted or upper part of the typical high school class. It was proposed that the talented student be helped through the preparation of supplemental material for use in the text, perhaps as fine print, and more particularly, through the production of a series of special monographs." [2]

The first draft of the course was tried in 25 high schools in academic year 1960–61. It has been rewritten twice and will be published in final form in the fall of 1963 under the title "Chemistry, an Experimental Science." The course was taught to approximately 12,000 students by 158 teachers in 125 schools in the last academic year.

The course places great emphasis on the experimental nature of science. While the CBA course begins with an experiment using a black box, the CHEM study course begins by asking the student to observe a burning candle and to write down all he sees. Most students make 6 to 12 observations. Then the teacher refers the class to a page in the text describing a professional chemist's 53 observations on a burning candle. The student becomes aware at once that his powers of observation can be improved. The first lesson is a starting point for the study of the production of phase changes—solids, liquids, and gases, combustion, and chemical reactions. Like CBA's course, CHEM develops scientific models for the atomic theory and demonstrates with these models, as well as with laboratory equipment, how atoms are combined in substances. The course is closely coordinated with the laboratory manual, which contains open-end experiments. As the course progresses, students receive fewer directions on experiments. The laboratory section specifically illustrates or demonstrates chemical theories or principles. The latter parts of the course use many concepts and principles covered in earlier chapters.

Four chapters include work with the periodic table to give the student an opportunity to note the periodicity of elements. The last chapter is on biochemistry.

In both projects students record their laboratory observations in a blank laboratory notebook having carbon

[2] *CHEM Newsletter*, vol. 1, No. 1, November 1960.

### Safety in the laboratory . . . .

SAFETY in the laboratory is a subject of major importance. Many educational, professional, and commercial organizations are alert to the need for material that will help the school prevent accidents. The Manufacturing Chemists' Association's new film, "Safety in the Chemical Laboratory," though primarily designed for colleges, has many suggestions that apply to high school laboratories. A recent series of articles on safety in the chemical laboratory in the *Journal of Chemical Education* offers much help in spotting potential hazards in the laboratory. Every teacher should have the National Safety Council's two leaflets, "Laboratory Glassware" and "Chemicals in the Laboratory," which identify two areas of laboratory work as prime sources of laboratory accidents. Alpha Chi Sigma, the chemistry fraternity (5503 East Washington Street, Indianapolis 19, Ind.), has large posters on safety in the chemical laboratory for 10 cents each.

—ROBERT L. SILBER.

paper between the sheets. The student retains the carbon copy of his work. This system prevents the use of fill-in-the-blank questions and avoids regimentation.

The CHEM study project is also developing a series of 16-mm. color motion pictures to further facilitate the learning of chemical principles and concepts. Eight films are now available; CHEM plans to produce about 30. Those produced are available from the CHEM study project for a reasonable price.

The project is also planning to develop a series of monographs on specific subjects, possibly one monograph on each chapter of the text, for students interested in a particular subject or for superior students seeking additional information.

One of the most helpful aids the project is developing is a teacher's guide. Each chapter of CHEM's guide corresponds with a chapter in the text and follows a prescribed format of eight sections. The first section develops the intent and method of the chapter. The second briefly discusses the related ideas in the text. The third develops a short list of items on the nature of the concepts the chapter has presented. The fourth develops a time schedule and proposes assignments. The fifth goes through a section-by-section discussion of the chapter and lists typical questions students ask. The sixth contains supplementary material, such as lists of films, monographs, articles, and books for student reading and teacher reference. The seventh contains a background discussion on chemical principles and scientific philosophy. The final section contains answers to exercises and problems given in the textbook.

The teacher's guide is a valuable instrument that can be used by the experienced CHEM study teacher and by the teacher planning to initiate a CHEM study course. The guide may be the answer to the often-asked questions "How can we afford to retrain or update all the science teachers in the country?" and "Can a chemistry teacher who has not attended a CHEM study or CBA institute teach such a course?"

In addition to the text, laboratory guide, films, monographs, and teacher's guide, the CHEM study has also been preparing wall charts on such subjects as the names and formulas of common ions, the relative strength of acids and bases, and the orbits of atoms.

CHEM has established nine regional centers. Each week teachers in a region using CHEM materials report to a center for several hours to ask questions on the project and to report on teaching various parts of the course. The centers help teachers and allow project directors to obtain feedback on the teachability of a section.

Another course that was developed recently is the Encyclopaedia Britannica's film series, "Modern Chemistry," a complete introductory course in chemistry taught by John F. Baxter of the University of Florida. The series includes 160 lectures and laboratory demonstrations running a half hour each. The films fit into daily class schedules and qualify students for full academic credit. Student and teacher manuals accompany the course. The films are available from Encyclopaedia Britannica Films, Inc., Wilmette, Ill., either as a set or in lesson series.

## Reading material for the chemistry teacher

One of the best sources of current information for the chemistry teacher is the *Journal of Chemical Education*—often called the "living textbook of chemistry." The teacher who reads the *Journal* regularly keeps abreast of events in chemistry and can add new ideas to his course as he goes along. Special features of the *Journal* include "Tested Demonstrations," which the teacher can use in presenting principles and concepts, and a chemical instrumentation section, which explains in detail the workings of new chemical instruments. A section on "Research Ideas for Young Scientists" describes projects that students can conduct by themselves. A subscription to the *Journal* is a must for every chemistry teacher—as well as for every school library.

Another good source of current information is the *Scientific American*, a journal representing all the sciences. It publishes articles by leading scientists in a style for teacher and layman alike. A minimum reading of one article a month will go far toward keeping the teacher's information up to date.

To keep up with education practices, the teacher should read the educational supplement of the *Saturday Review*, which comes out once a month. Articles by leading educators on all subjects in education make up a major part of the supplement.

A recent publication, "Aids and Sources for the Science Teacher," prepared cooperatively by several scientific societies should be helpful to teachers. It reports on various materials, sources of information, and services available from the participating societies: The American Astronomical Society, American Chemical Society, American Geological Institute, American Institute of Biological Sciences, American Institute of Physics, and American Meteorological Society. Any one of the societies can supply a copy of the publication.

The paperback book is a breakthrough in the presentation of quantities of materials at low cost. Several series of monographs are available to assist student and teacher in pursuing chemistry beyond the classroom. They include the Physical Science Study Committee series, the National Science Teachers Association's "Vistas of Science," the chemistry series of Prentice-Hall, and the

chemistry monographs of the Reinhold Publishing Co., and the monographs of the Royal Institute of Chemistry.

### Other aids for the teacher

Science kits are a relatively new way of introducing students to various aspects of science.

Programed instruction is another major contributor to the enhancement of the process of learning. Several commercial companies are working on programed courses in the sciences. Programed instruction is available in many forms, but we still need more experimentation regarding its proper place in the curriculum. Both CBA and CHEM are investigating the programing of parts of their courses; it may be possible to program related areas, such as sections on mathematics review, exponential numbers, and the metric system.

Teaching innovations include the use of television. The program "Continental Classroom" for teachers and students is a prime example of the use of this device.

A new book, "Laboratory Planning," prepared by the Committee on Design, Construction, and Equipment of Laboratories of the National Research Council is now available from the Reinhold Publishing Co. Although it is directed to the college level, some of the suggestions are applicable to the high school laboratory.

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## *Resources for improving instruction in physics*

R. W. LEFLER

*The new practices in physics teaching described by Mr. Lefler in this article, excerpted from his speech to the conference, have, he said in his opening remarks, grown out of the rebellion of students and teachers against the "stultifying effects" of the old method of teaching science as a fixed body of knowledge and are moving toward the "spirit and process of inquiry."*

NEW RESOURCES in physics teaching include the curriculum developed by the Physical Science Study Committee, the work of professional associations, new books and publications, demonstration tools, audiovisual aids, and the visiting science program.

### Curriculum

The most important of the new high school physics curriculums is the physics course of the Physical Science Study Committee, a group organized in 1956 at the Massachusetts Institute of Technology under J. R. Zacharias. The project has the support of the National Science Foundation, the Ford Foundation, the Alfred P. Sloan Foundation, and the Fund for the Advancement of Education.

PSSC's "package" includes a textbook, laboratory guides, laboratory materials, educational films, monographs, a four-volume teacher's guide, and testing material. Its philosophy is to provide a carefully prepared explanation of selected materials reinforced by films and laboratory work. PSSC's curriculum centers around the idea that matter and energy are conserved, and that the concepts of space, time, and matter cannot be separated. It sacrifices technological examples. Its laboratory guides suggest experiments using simple apparatus and are well coordinated with the text. The films—44 in all—help the teacher with new techniques, present phenomena the student cannot otherwise observe, supplement the text with added explanations of difficult concepts, and show scientists at work. In my opinion, these films far surpass any others on the subject. Most of them will strengthen a good physics course. Educational Testing Service has developed tests for the course which emphasize the application of principles, not the recall of information.

In addition, PSSC has produced about 24 monographs in a Basic Study Series for "free"—not required—reading to add to the student's understanding of basic concepts.

The PSSC course is a demanding one. Students not highly motivated may not stay with it. But it is strengthening texts and curriculums. It has, for instance, moved some material previously taught in high school physics to earlier courses. It pays less attention to technological application (sometimes to the dismay of those anxious lest students be guided away from engineering), gives more attention to basic concepts, and places more emphasis on laboratory instruction than earlier texts do. Some of its material was formerly used only in college courses. In other words, more is expected of the high school student of physics than previously.

PSSC is extending its initial course through an Advanced Topics Program. It has completed chapter A–1,

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"Angular Momentum and Its Conservation," and is preparing other chapters on atomic structure and the special theory of relativity. It has also produced a preliminary edition of a laboratory guide which presents suggestions for experimental studies of angular momentum, moment of inertia, angular acceleration, the Michelson interferometer, waves in a moving medium, and spectra. For more information write to Educational Services, Inc., 164 Main Street, Watertown, Mass.

## Professional associations

The two principal professional associations working to improve teaching in physics are the American Institute of Physics and the American Association of Physics Teachers.

The Institute is a corporation of the five principal physics societies, joined for the purpose of advancing the science of physics and the diffusing of knowledge about it and its application to human welfare. It publishes journals; informs the public of progress in physics; has a comprehensive program to strengthen physics education at all levels; cooperates with other physics organizations; works for unity among those working with physics—researchers, teachers, and technologists; and fosters the relation of physics to other sciences, the arts, and industry.

The association works to improve physics teaching and the appreciation of physics and physics teaching by the public. Ten percent of its members are high school teachers. Its education programs include a wide range of special projects and activities.

The association will launch a new journal for high school teachers of physics which it may call the *American Physics Teacher*. The first issue will be off the press early in 1963. The new journal will cover physics and pedagogy for the high school physics teacher as the *American Journal of Physics* does for the college teacher. It will encourage him to continue scholarly study of physics and will emphasize the problems of content, organization, and methods of teaching high school physics. It should also be valuable to those teaching first-year courses in college, especially the teacher of terminal physics in the junior college. The two journals should improve communications between secondary school and college teachers of physics.

## Paperback books

AAPT is preparing for publication by D. Van Nostrand Co. a series of paperback monographs—Momentum Books—to provide lucid, accurate expositions of important topics in physics for students who have had only a good introductory course in college physics. Each title is a topic either not treated at all or not fully treated in introductory physics courses. Contracts have been signed for these topics: The discovery of the electron; temperatures, very low and very high; radio exploration of the planetary system; waves of oscillation; physics of musical sounds; crystal imperfections; and elementary particles.

## Demonstration tools

AAPT expects to publish in 1965 a reference text containing discussions of the best demonstration equipment and techniques developed in the last 20 years. The great variety and number of these demonstrations, as well as their complexity and specialization, make it impossible for one person to prepare a uniformly high quality text that adequately surveys them. A team of six physicists under Harry F. Miners and Robert Resnick at Rensselaer Polytechnic Institute are preparing the text, to be called "A Reference Source for Demonstration Experiments in Physics." It will describe in full the nature, significance, and use of one-third to one-half of the demonstrations it will contain, complete with shop drawings. Other descriptions, though brief, will be sufficient to help the teacher reproduce them with little difficulty. Chapters will have such titles as "A Comparison of Various Forms of Demonstration Techniques," "The Use of TV as a Magnification Tool," "The Advantages and Limitations of Closed Circuit TV," and "The Overhead Projector in the Physics Lecture." The text will contain instructions on how to prepare a corridor demonstration; descriptions of specific techniques, such as the use of stroboscopes; and a list of selected long and short classified films. It will emphasize demonstrations related to the fundamental concepts of contemporary physics, e.g., standards of length and time; kinetic theory; quantum effects; scattering and resonance phenomena; electric and magnetic field patterns; wave phenomena; analog techniques; and the use of models, such as those for crystals, accelerators, and particle detectors. Much of the book will be directly useful to high school physics teachers.

The association's 1938 text "Demonstration Experiments in Physics" is still a valuable book of demonstration suggestions which, with the new reference, will cover classical and modern physics.

## Audiovisual aids

AAPT's Visual Aids Committee and Commission on College Teaching, PSSC, the Science Teaching Center of the Massachusetts Institute of Technology, and Educational Services, Inc., are producing several types of teaching films. Though most of them are for college use, their content will overlap enough to make them of interest to high school teachers. From the Educational Services, Inc., library of wave effects they have produced a set of

nine silent films called "Filmed Demonstrations on Ripple Tank Wave Phenomena." Their lecture-demonstration films are on reflection and refraction, interference and diffraction, barrier penetration, and ultimate speed.

New films in PSSC's series which will be available in the coming year are on E.M.F., electrical potential energy, and linear momentum. For information on PSSC films write to the Film Studio of Educational Services, Inc., or to Modern Talking Picture Service, Inc., 3 East 54th Street, New York 22, N.Y.

Under a grant from the National Science Foundation, the Ohio State University is producing short (30-second to 3-minute) films in physics for classroom use to illustrate essential but difficult-to-demonstrate concepts. They are designed so that the teacher can develop the subject in his own way, use the film, and go on with his lecture.

The Bell Telephone Co. has produced some effective films and teaching devices, such as the wave-motion demonstrator and the sun battery. Managers of local Bell telephone offices can furnish information on them.

The *American Journal of Physics* beginning in October 1962 will review modern physics films and carry a critical bibliography of films produced in the 1950's or earlier. Ten university film libraries will stock these films.

Issues of the *American Journal of Physics* for April 1961 and May 1962 list over 600 films useful in physics instruction, from elementary to graduate school.

## Apparatus for demonstrations

Within the last few years more and more schools have been using an overhead projector with a 10- by 10-inch stage for projecting slides, transparencies, and experimental arrangements. Walter Eppenstein of Rensselaer Polytechnic Institute has published a report, "The Overhead Projector in the Physics Lecture," which summarizes the results of a project to develop new techniques, accessories, and experiments for the 10- by 10-inch projector. His report discusses the production and use of transparencies, the overhead projector as a means of projecting demonstration apparatus, a breadboard for electrical connections in projecting circuits, and an x–y plotter for the projector. Some of the demonstrations described include a crystal model in which the "crystal" is built up atom by atom through layers of transparent overlays, animated slides of such phenomena as a wave moving across a boundary, and a kinetic theory chamber. The book costs $1 and is available from the Rensselaer Supply Store at the Institute in Troy, N.Y.

Another source of information on demonstration apparatus is the AAPT Committee on Apparatus (335 East 45th Street, New York 17, N.Y.). Both the Association and the American Institute of Physics are studying a proposal to establish an apparatus center for physics instructional equipment to provide a place for displaying, using, and evaluating apparatus.

## Other aids

The improvement of physics teaching requires local activity by physicists since precollege education is primarily the responsibility of the city, county, or State. If the full benefits of national efforts are to be realized, professional societies must obtain the help of physicists familiar with local educational problems. AAPT and AIP have established the Regional Counselor Program in Physics to help solve local problems. Nearly every State has a regional counselor, whose name can be obtained from AIP. Local conditions determine each counselor's program. In one State he may arrange for consultants to work with a curriculum committee; in another he may serve with an industry-education committee working to improve teaching conditions. This program is an added means of communication between physics teachers and educational research physicists.

Nearly all State academies of science operate a visiting scientists program under a grant from the National Science Foundation. The program works in this way: a school invites a physicist to visit it as a guest and colleague to lecture or to hold informal conferences with students, staff members, and administrators on problems in physics and physics teaching. For more information write to the Visiting Scientists Program in Physics at AIP. Requests for visiting physicists, however, should be sent to the State chairman of the Visiting Scientists Programs.

AIP's placement service yearly compiles a list of about 100 organizations offering summer employment opportunities to college physics teachers, high school physics teachers, and physics students. For information write to the placement service at AIP.

Physics groups are preparing some programed instructional material in physics. Write to the Center for Programed Instruction, 365 West End Avenue, New York 25, N.Y., for information.

## Publications

The American Institute of Physics has several useful publications. Among them are these:

"Laboratories and Classrooms for High School Physics," a reprint of chapter 12 in the book, "Modern Physics Buildings: Design and Functions," prepared by AAPS and AIP, with support from Educational Facilities, Inc.

"Physics in Your High School," a handbook for the improvement of physics instruction. It discusses ways of helping the physics teacher to keep up to date, suggests course content, and lists books and laboratory equipment.

"Why Should You Study Physics in High School" (1959) is a booklet encouraging 9th- and 10th-graders to plan for a course in physics.

"Careers in High School Physics Teaching" (1962) encourages qualified young people to consider careers as high-school physics teachers. It contains brief reports by five practicing teachers on their experiences and satisfactions as teachers. The booklet also takes up the topics of the demand for high school teachers; education needed by teachers; duties of teachers; and salaries, workload, and fringe benefits. Information is specific.

"Rewarding Careers for Women in Physics" (1962), for young women considering careers in physics, is a realistic picture of opportunities and problems.

The five booklets are available from the Education Department of AIP.

The National Science Teachers Association (1201 16th Street NW., Washington 6, D.C.) has three useful publications:

"Ideas for Science Projects," a 51-page booklet on project development, project ideas, sources of ideas, and techniques. Its price is $1.

"Planning for Excellence in High School Science," a 67-page booklet on the nature of each of the educational and scientific enterprises and their meaning for secondary science, administration, supervision, and teacher training. (For a review of this book, see pp. 865–66 of the December 1961 *American Journal of Physics.*)

"School Facilities for Science Instruction," the 1962 revision. This is a useful book for the teacher, administrator, or architect on the building of a new facility or the remodeling of an old.

As an outgrowth of its traveling science library, the American Association for the Advancement of Science (1515 Massachusetts Avenue NW., Washington 5, D.C.) has published annotated bibliographies of science books for high school use, including a bibliography of paperback books for use in high-school science instruction.

"Aids and Sources for the Science Teacher," is a guide prepared cooperatively by the American Association of Physics Teachers, the American Institute of Physics, the American Astronomical Society, the American Chemical Society, the American Geological Institute, the American Institute of Biological Sciences, and the American Meteorological Society. Its purpose is to identify the programs of scientific societies useful to the science teacher, and its best use is as a source book for locating the various forms of assistance. Obtain from one of the sponsoring societies.

For information on teacher education and certification I recommend "Guidelines for Preparation Programs of Teachers of Secondary School Science and Mathematics," from the American Association for the Advancement of Science. It is a set of recommendations prepared by the National Association of State Directors of Teacher Education and Certification and the AAAS.

For a serious study of teacher assignments, scheduling, and organization of the school to make it possible for teachers to participate in more scholarly activities and students to assume more responsibility for learning, write to the Commission on the Experimental Study of the Utilization of the Staff in the Secondary School, National Association of Secondary School Principals, 1201 16th Street NW., Washington 6, D.C., for a copy of "Focus on Change—Guide to Better Schools."

## Recognition for teacher and school

The American Association of Physics Teachers, with the help of the Carnegie Corp., is starting a program to recognize high school teachers outstanding in their mastery of physics. The association hopes the program will encourage teachers to strengthen their abilities and improve their knowledge of physics. Recognition will be given on the basis of examination and observation. Any teacher who has served in a secondary school for 3 years is eligible. He need not be a physics major. The tentative date for the first examination is a Saturday late in October or early in November 1962.

High school and college teachers are writing the examinations, with the cooperation of the Educational Testing Service. One-half (2 hours) of the examination will be given to multiple-choice questions; the other 2 hours to essay questions and problems. After the examinations have been scored, inquiry will be made on the teaching of those with high scores. AAPT believes that it will find a high correlation between competence in subject matter and performance in the classroom—the mastery of a subject should be an aid to good teaching. Although no monetary award accompanies the recognition, the status of the teacher receiving the award should be enhanced.

Questions about the program should be addressed to J. W. Buchta, Johnston Hall, University of Minnesota, Minneapolis 4, Minn.

AAPT's High School Awards Committee has picked 10 high schools to be honored for their outstanding physics programs in each of the last 4 years. Six of the schools are chosen from six regions of the United States; the other four without geographic restriction, though no two schools of the same size are chosen from the same region.

Send nominations to the committee's chairman, Stanley S. Ballard, Department of Physics, University of Florida, Gainesville, Fla.

—R. W. LEFLER.

HERMAN R. BRANSON

# *Introducing newer concepts of physics*

*Here, in essence, is Dr. Branson's own condensation of his address to the science supervisors and consultants. He illustrated his point with a demonstration.*

MODERN PHYSICS is an enormously complex field—American universities list 213 distinct specialties for graduate study, running from acoustics through X-ray technology. In spite of this diversity and complexity, physics attempts to describe the universe of phenomena in terms of a few concepts. Unfortunately, general statements really do little to aid a student in understanding the problems he is studying. I believe, however, that we can acquaint the student with the newer developments in physics by analyzing some simple early experiments and showing him how the concepts, methods, techniques, and procedures have been developed or modified in contemporary applications.

One of the experimental research areas of the Department of Physics at Howard University is mass spectroscopy: The finding out of just how much of certain isotopes are present in a given sample. In going back to the prototype apparatus of our equipment, we find a simple evacuated glass tube—the Thomson tube first used by J. J. Thomson in the Cavendish Laboratory at Cambridge University some 60 years ago—which has led to the major large installations of modern physics: The synchrocyclotrons, bevatrons, linear accelerators and the like. [At this point, Dr. Branson began his demonstration.]

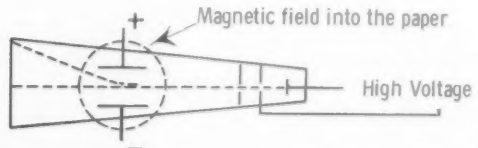


Diagram of speaker's demonstration with a Thomson tube

Observe what happens when a high voltage is applied to the end electrode. Observe how the beam is bent on passing through a magnetic field and how it is attracted by a plate connected to the positive terminal of a voltage source. The end of the tube is covered with a fluorescent layer in order to detect the beam.

To fit these observations into a consistent pattern, Thomson employed certain concepts and principles. Since the beam did not behave as an ordinary light beam, it seemed reasonable to assume that it was composed of charged particles. And our observations show that they are negatively charged. Careful observation of a different tube would show that the curved path we saw was really part of a circle. For circular motion we have some long-established relations that we can call on. One is the equality of forces, wherein

$$\frac{Mv^2}{R}=Bqv$$

In this equation, $M$ is the mass of each particle; $v$ is its velocity; $R$ is the radius of the path it follows; $B$ is the magnetic field (called the magnetic induction); and $q$ is the charge of the particle. Algebraic manipulation yields

$$R=\frac{Mv}{Bq}$$

as the radius of the curved path followed by the particles. Here the simple equation leads to our mass spectrometer or the cyclotron, for if we multipy by $2\pi$ and divide by the velocity ($v$) we have

$$\frac{2\pi R}{v}=\frac{2\pi M}{Bq}$$

Here the left hand side is nothing more than the distance traveled in one rotation (the circumference) divided by the velocity. Distance divided by velocity equals time, and this time is that for one revolution of our charged particle of mass, $M$, and charge, $q$; the important result is that this time, called the period $T$, is then

$$T=\frac{2\pi M}{Bq}$$

so that for particles of the same charge and mass in a constant magnetic field ($B$)$T$ is constant. This simple result makes the cyclotron possible.

*Dr. Branson is head of the Physics Department, Howard University.*

The mass spectrometer employs the same basic equation in a slightly different fashion. Since we cannot easily determine the velocity ($v$) we make use of the fact that the velocity is imparted by our voltage source in the kinetic energy,

$$\tfrac{1}{2}Mv^2 = qE$$

where $E$ is in volts. Thereupon

$$\frac{M}{q} = \frac{B^2R^2}{2E}$$

Thus if we keep the magnetic field ($B$) and the voltage ($E$) constant, particles of the same charge but different $M$ will follow paths of different radii and may thus be separated.

Thomson eliminated the velocity by balancing the electric force against the magnetic, since $E$ and $B$ are easier to measure. He then found that

$$\frac{E}{B} = v$$

$$\frac{q}{M} = \frac{E}{B^2R} = 1.76 \times 10^{11} \frac{\text{coulombs}}{\text{kilogram}}$$

A knowledge of the fundamental techniques (and accompanying concepts) is important to the understanding of recent developments in physics. In looking at the simple experiment with the Thomson tube, we see that we need to (1) produce a vacuum; (2) produce charged particles; (3) generate, stabilize, and control high voltage; (4) produce a magnetic field; and (5) detect particles.

You might lift out these five items and use them as a guide in explaining contemporary research in molecular, atomic, and nuclear physics to your students, for they are employed in all recent work, usually together and certainly individually.

The basic equations which we used might be grating on some of us who observe that the force exerted by the magnetic field is not along its direction. To continue our analysis to where we get these forces right would lead to vector analysis and the Lorentz equation for the force,

$$\bar{F} = q\bar{E} + q\bar{v} \times \bar{B}$$

where all the quantities have both magnitude and direction except the charge ($q$) and the $\bar{v} \times \bar{B}$ is interpreted to yield the correct direction for the force ($\bar{F}$).

A most revealing extension of one of our basic equations is that for kinetic energy. If in one of our experiments, a descendant of our Thomson tube experiment, we raised the voltage ($E$) to larger and larger values, the speed of the particles would not continue to increase but level off approaching a constant value ($c$), which proves to be the speed of light in empty space. The correct relation is found to be

$$\text{Kinetic energy} = M_o c^2 \left[ \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right]$$

when $M_o$ is called the rest mass. This relation leads unerringly to the most famous equation of our time, the Einstein relation,

$$\text{Rest energy} = M_o c^2$$

and states also the surprising result that the mass of a body is not constant but increases with speed

$$M = \frac{M_o}{\sqrt{1 - \frac{v^2}{c^2}}}$$

These three equations are the basis of modern nuclear physics. We see here how they fit naturally into a conceptual scheme devised to accommodate magnetic and electrical fields acting on moving charged particles into a consistent and integrated panorama of the physical world.

By following the proliferation of the ideas introduced to describe the observations of a simple but deep experiment, we can gain genuine knowledge—an agreeable situation which stems from a basic goal of physics: The representation of all physical phenomena in a consistent scheme with a minimum of concepts, hypotheses, principles, and laws.

### Selected References


Beiser, Arthur. ed., *The World of Physics*, New York, McGraw-Hill Book Co., Inc., 1960.

Blin-Stoyle, R. J., and others, *Turning Points in Physics*, New York, Harper & Bros., 1959.

Einstein, Alfred, and Leopold Infeld, *The Evolution of Physics*, New York, Simon & Schuster, 1961.

Peierls, R. E., *The Laws of Nature*, New York, Charles Scribner's Sons, 1961.

Rohrlich, F., "The Classical Description of Charged Particles," *Physics Today*, vol. 15, No. 3, p. 19, 1962.

Semat, Henry, and H. E. White, *Atomic Age Physics*, New York, Rinehart & Co., 1959.

Shamos, Morris H., ed., *Great Experiments in Physics*, New York, Henry Holt & Co., 1959.

Sherwin, Chalmers W., *Basic Concepts of Physics*, New York, Holt, Rinehart, and Winston, Inc., 1961.

ROBERT C. STEPHENSON

# *The new curriculum in earth sciences*

*Today, Dr. Stephenson says, the earth is being rediscovered by scientists who are finding the complex unsolved problems a match for their most sophisticated levels of instrumentation and thinking. Their interest has been stimulated by a number of things: The geological and geophysical exploration for mineral resources during World War II, the nuclear developments, the International Geophysical Year, the advent of the space age, and, in the past decade, by greater understanding of the basic concepts of science and the development of instrumentation that make more exacting research studies of the earth and its environment possible. Now, he says, earth science is being rediscovered by the schools. Here, in condensed form, is Dr. Stephenson's discussion of the values of and problems in teaching earth science.*

AT THE TURN of the century geology or physical geography was a common high school subject, but as biology and general science were added to the curriculum this course all but disappeared. Now in schools across the land it is riding the crest of a wave of interest, a wave that began to build up before Sputnik I, which is widely credited with sparking the revolution in science education.

As early as 1955 New York State, after experimenting with an earth science course, adopted its first syllabus and by 1958 was well on its way to adopting a statewide course. By 1959, when Pennsylvania published its *Teaching Guide for Earth and Space Science Course* (14),[1] some States had already started introducing earth science materials.

Pennsylvania's introduction of the earth science course stimulated other schools and by 1961, at least 24 States had initiated courses or were planning to initiate courses or units, most of them at the ninth-grade level.

## *What is earth science?*

It is hard to find a definition of earth science, and most of those available are poorly conceived or are not completely compatible with scientists' ideas. It is, however, the science that deals with the scientific phenomena of the earth and its environs in space and is composed of a family of interrelated fields of science including geology, geophysics, oceanography, meteorology, and astronomy. It deals with a scientific system composed of the lithosphere, hydrosphere, atmosphere, and space. The tools of chemistry, physics, and mathematics are essential to the study of earth sciences.

## *Why teach earth science?*

There are several reasons why schools should teach earth science; among them are the following:

It contributes to our understanding of our physical and biological environment.

It increases our understanding of the esthetic qualities in many phenomena of geology, meteorology, and astronomy, and therefore our enjoyment of them.

It disciplines the mind and develops the reasoning powers of an intelligent person.

## *At what grade levels should earth science be taught?*

The subject matter of earth science can be introduced into the school science program at all stages, from kindergarten through grade 12. The ninth grade appears, however, to be the ideal level for a full course for these reasons:

1. Revised science curriculums have pushed the general science courses downward and left a gap at the ninth-grade level.

2. Most ninth-grade pupils have acquired the reading ability necessary to master the basic subject matter of science.

3. If it is taught by well-prepared teachers, it can illustrate the interdependence of various basic sciences.

4. It can stimulate pupils' interest in the methods of scientific inquiry and investigation that are essential to mastery of subsequent basic science courses.

A semester course in earth science in grades 7 to 10, or as short units in general or physical science courses will at best be shallow and generalized, will not contribute greatly to the college-bound student, and may be a waste of time except as a watered down course for pupils of less than college ability.

A 12th-grade course in geology or one of the other earth

[1] The figures in parentheses refer to the numbered items in the list of references, page 26.

*Dr. Stephenson is Executive Director of the American Geological Institute.*

sciences offered to students who have completed courses in biology, chemistry, and physics can be of college caliber.

### *What is the subject matter?*

The sequential nature of the subject matter in earth sciences should be considered; for example, much of what is taught in beginning geology courses in college is not beyond the comprehension of upper elementary school children. Certainly the basic facts of geology on classification of rocks, minerals, and fossils are not beyond the reach of the average elementary school pupil.

At the ninth-grade level the earth science course should emphasize concepts and problems, not the assimilation of predigested facts. The *AGI Geology and Earth Sciences Sourcebook* (8) devotes considerable attention to both concepts and problems. The course should have a solid laboratory program, and it will be more effective if it includes field trips and classroom instruction in the phenomena of the geographic area. The balance between the various subject-matter areas will vary from course to course. The Pennsylvania Guide (14) recommends the following balance: Introduction, 2 weeks; the changing earth, 11 weeks; the earth in space, 9 weeks; weather and climate, 9 weeks; and the oceans, 2 weeks.

The ninth-grade course offers students opportunities to draw on mathematics, chemistry, and physics and to read and investigate independently.

### *What teaching resources are available?*

Since earth science has not been taught in most schools for the past several decades there has been little incentive to develop learning aids. Now with the number of courses rapidly increasing, organized teaching materials are greatly needed. Teachers guides, laboratory manuals, laboratory and classroom experimentation and demonstration equipment, and audiovisual aids are all needed. Because of the rapid developments in earth sciences and the new level of sophistication in secondary school science resulting from the massive efforts at improvement in the last several years, textbook requirements must be reexamined and new materials must be developed.

Because of the shortage of teaching materials and because the production of new materials will take time, the teaching resources, such as they are, must be used to the fullest extent. The earth science texts (7, 10, 16, and 17) can be augmented by publications for teachers (8, 9, 12, and 14). (No 14, which was developed by a group of geologists, astronomers, and meteorologists working with the Pennsylvania State Department of Public Instruction, sets a new standard of subject-matter content.)

There is no integrated series of teaching films covering earth sciences, but the *Directory of Geoscience Films* (6) lists over 500 films related to earth science; some are excellent for educational purposes.

Educational materials are available from several scientific societies, including the American Astronomical Society, the American Geological Institute, the American Meteorological Society, the Committee on Oceanography of the National Academy of Sciences—National Research Council, and the National Aerospace Education Council. The Geology Reference Series S–1, *Sources of Geological Information* (2) lists State geological surveys from which low cost or free educational materials related to geology may be obtained. Educational aids are also available from government agencies, for example, *Project Ideas in the Earth Sciences* (18) from the U.S. Geological Survey.

Administrators of earth science courses are plagued by the difficulty of selecting from widely scattered resources and of distinguishing between good and poor resources. For example, they may be encouraged to load up on inferior materials, some of them useless, while scientifically acceptable materials are being produced. Scientists from the various areas of the earth sciences can, through their assistance, help solve these and other problems.

### *Can trained teachers be found?*

Probably the biggest problems facing the successful adoption of earth science in secondary schools are those of developing trained teachers and retraining science teachers in service to teach earth science. The National Association of State Directors of Teacher Education and Certification and the American Association for the Advancement of Science in their *Guidelines for Preparation Programs of Teachers of Secondary School Science and Mathematics* (11) recommend that the teacher of earth science courses have a background in biology, chemistry, and physics with courses in the various earth sciences—astronomy, meteorology, geology, etc. This preparation, though ideal, is not realistic, since such depth in scientific subject matter is not possible in usual teacher training. A graduate with a degree in earth sciences will be deficient in education courses and a graduate of a school of education will be deficient in subject matter. It appears, therefore, that science graduates can best fill the needs.

The problem of training existing science teachers to teach earth sciences is one of considerable magnitude. Teachers of biology, chemistry, and physics may be competent in their own field, but incompetent in earth sciences; very few will have had training in oceanography, meteorology, or geology. Without basic background they cannot be expected to distinguish between good and bad earth science.

Summer institutes, academic year institutes, and in-service institutes sponsored by the National Science Foundation have provided training for some teachers of earth sciences, but there have been far too few of them to meet the demand. If earth science is to achieve its rightful place in the school science programs, a great deal of effort will be needed to solve the teacher training problem. Specific programs of training must be designed for new teachers and institutes, and inservice programs must be improved and greatly accelerated to equip existing teachers to teach earth science courses.

### *Is earth science here to stay?*

Whether or not earth science is here to stay depends on how serious we are about having it stay. Much time, energy, effort, and money will have to be invested in teaching resources and teacher training if it is to become a solid part of the school science curriculum. Some professional associations and groups are already making great efforts—some are producing materials, films, and other materials. Others are making plans; for example, the American Geological Institute has submitted a proposal to the National Science Foundation for a secondary school (ninth grade) curriculum improvement program in earth sciences similar to PSSC and BSCS.

#### Selected References


1. American Geological Institute, *Dictionary of Geological Terms*, Dolphin Reference Series, Garden City, N.Y., Doubleday & Co., Inc., 1962. 545 pp.

2. American Geological Institute, *Geology Reference Series for Science Teachers* (a pamphlet series), S–1—*Sources of Geological Information;* S–2—*Selected References for Earth Science Courses;* S–3—*Films for Earth Science Courses*, American Geological Institute, Washington 25, D.C.

3. American Geological Institute, *Shall I Study Geological Sciences?* Washington 25, D.C., American Geological Institute, 1962. 14 pp.

4. Boeck, Clarence H., The Place of Earth Science in the Science Curriculum, *Current Science* (teachers' edition), vol. XLVI, No. 31, 1961, Education Center, Columbus, Ohio.

5. Caldwell, Loren T., The New Role of Earth Science in Emerging School Science Programs, *GeoTimes*, vol. V (March 1961), pp. 26–28.

6. Dort, Wakefield, Jr., *Directory of Geoscience Films*, Washington 25, D.C., American Geological Institute, 1962. 63 pp.

7. Fletcher, Gustav L., and C. Wroe Wolfe, *Earth Science*, Boston, Mass., D. C. Heath, 1959. 564 pp.

8. Heller, Robert L. (ed.), *Geology and Earth Sciences Sourcebook for Elementary and Secondary Schools*, New York, Holt, Rinehart and Winston, Inc., 1962. 496 pp.

9. Linder, Wade, and Roland B. Bartholomew, *A Teaching Guide for Earth Science Teachers* (tentative), Palo Alto Unified School District, Palto Alto, Calif., 1960. 74 pp.

10. Namowitz, Samuel N., and Donald B. Stone, *Earth Science—The World We Live In*, New York, D. Van Nostrand Co., 1960. 614 pp.

11. NASDTEC–AAAS, *Guidelines for Preparation Programs of Teachers of Secondary School Science and Mathematics* (Appendix, Earth & Space Science), Washington 5, D.C., National Association of State Directors of Teacher Education and Certification—American Association for Advancement of Science, 1961. 32 pp.

12. New York State Education Department, *Earth Science Syllabus*, 1955; *Earth Science Handbook*, 1961, Publications Distributions Unit, Finance Section, New York State Education Department, Albany 1.

13. Odishaw, Hugh, *Science Explores Our World*, Columbus 16, Ohio, American Education Publications Center, 1958. 48 pp.

14. Pennsylvania Department of Public Instruction, *Teaching Guide for the Earth and Space Science Course*, 1959. 103 pp. (Reprints available from National Aerospace Education Council, Washington 6, D.C., revision in press June 1962).

15. Pennsylvania Department of Public Instruction, *Earth and Space Guide for Elementary Teachers*, 1961. 82 pp. (Reprints available from National Aerospace Education Council, Washington 6, D.C.)

16. Ramsey, William L., and Raymond E. Burckley, *Modern Earth Science*, New York, Holt, Rinehart and Winston, Inc., 1961. 630 pp.

17. Trinklein, Frederick E., and Charles M. Huffer, *Modern Space Science*, New York, Holt, Rinehart and Winston, Inc., 1961. 550 pp.

18. U.S. Geological Survey, *Project Ideas in the Earth Sciences*, Washington 25, D.C., U.S. Geological Survey, 1961. 16 pp.

19. Willard, Gates, The School Science Teacher, A New Role for the Graduate Geologist, *GeoTimes*, vol. IV (May–June 1960), pp. 14–15, 34–35.

# *National developments in science curriculum in elementary and junior high schools*

PHILIP G. JOHNSON

*We have seen, Dr. Johnson says, elementary and junior high school science become less and less science, less and less discriminating and accurate observation made with a desire to understand and more and more a study about science from books and visual aids. Much of the essence of science has disappeared. Many courses of study being used, some of them developed or revised in the last year or two, are, he says, basically unscientific in their essence and organization; and many up-to-date and attractive textbooks published in the last year or two to support or replace these courses are less desirable than the old in the essence of science. Now scientists and educators are making massive plans for strengthening elementary and junior high school science. In his talk to the conference Dr. Johnson examined the major and more comprehensive of these plans, always looking for the promise of essence. Here, in summary, are his findings.*

THE 1961 REPORT of the Science Manpower Project at Columbia University proposes two dimensions to the elementary science plan. Its *planned dimension* recommends six major areas to be developed in grades 1 through 6. On each phase of an area, the report presents important generalizations, facts, and key questions. It suggests experiments and encourages laboratory work but proposes few specific experiments.

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A companion volume, also published in 1961, includes eight criteria for a good modern sequence in junior high school science, certain factors to be considered in designing an effective program, and 12 topics in science that are for the most part not different from those in other textbooks and courses of study. It offers few suggestions about activities and only limited ideas for experiments. In these "modern proposals," there is, in my judgment, no clear frame of reference, very little that is new, and very little that is of the essence of science.

IN JULY 1959 a group of investigators—scientists and educators—at the University of California, Berkeley, with financial support from the National Science Foundation, organized a major project in elementary school science. Their objectives are, Robert Karplus, physics professor and project director, has said, to reorganize the entire elementary science program around those "fundamental concepts, an understanding of which leads ultimately to an understanding of many diverse natural phenomena and to a feeling of familiarity with the natural environment"; to stress the concepts and methods of science rather than the uses and usefulness of science; and to learn what teachers and pupils can and cannot do. One goal of a science program is, they say, to emphasize the source of information, bring this source as close as possible to the pupils, and to discuss the role of authority in science. "We feel," they say, "that the longstanding benefits of science education consist of an understanding of the fundamental generalizations of the various fields and of the practice of inductive and analytical thinking that construction or discovery of these generalizations entails." The task of the teacher is therefore to use materials as a path to ultimate conclusion rather than as an end in themselves.

Although their purpose is not primarily to develop many successful units of work, they expect the topics they develop to be appropriate for elementary school use and to deal with a fundamental aspect of nature. So far they have developed three units—*coordinates*, *force*, and *what am I?*—and have begun work on two others—*structure of matter* and *animal coloration and natural selection.*

Dr. Karplus and his associates have not yet developed a clear program for elementary and junior high school science. In fact, they reported in 1962 that they would not attempt to construct a conceptual framework for the entire program until they had acquired enough experience to guide them in what a class could accomplish. Dr. Karplus has, however, discussed the basis of a program. He says:

> The two ideas, scientific literacy and scientific inquiry, might be the basis of a science program. . . . It is possible, however, that the focus of the science education should change as the children become older. For instance, the work in the early grades might stress scientific literacy . . . in the intermediate grades, there might be more stress on inquiry. In the junior high school, perhaps, the pupils' historical perspective may be adequate to permit a review of the way in which current unexplained causes were invented and replaced over primitive earlier ones. Such a curriculum

should provide a sound foundation for the teaching of the separate scientific disciplines in the high school and later. It would also produce scientifically literate graduates who might choose to study science further.

The California project has placed strong stress on what can be done to lead children to scientific inquiry, both by direct efforts of scientists and by classroom teachers who try to follow the ideas and materials proposed by scientists. Here, I believe, an important new dimension in elementary school science work has been brought into focus. The importance of careful observation, invention of concepts, use of arithmetic, recording and relating observations, development of operational definitions, planning experiments, analysis of ideas, and conceptualization are major contributions to the elementary and junior high school curriculum now emerging. Here, it seems to me, we can note the essence of real science.

THE ELEMENTARY School Science Project at the University of Illinois, Urbana, is directed by J. Myron Atkin of the College of Education and Stanley P. Wyatt of the Department of Astronomy. Their purpose is to present a plan for learning what can be done with children studying astronomy rather than a plan for an elementary and junior high school science program. A trial edition of their first product, *Charting the Universe*, was used in about 275 classrooms during the 1961–62 school year. This booklet should help pupils learn how the astronomer knows what he knows and how to work as an astronomer works. By its statements, illustrations, and descriptions of activities, it should help pupils understand such things as the shape and size of the earth, the size of the solar system, and orbit of planets.

The Illinois project has already shown that astronomers, as scientists, can work with teachers and other educators in developing a science series for schools. As such it makes a substantial contribution, for it reveals not only a way in which pupils can learn to understand astronomical information but also a way by which astronomers can help make science instruction more like the thinking of astronomers. Here again, I believe, we find the essence of science.

THE EDUCATIONAL SERVICES, Inc., of Watertown, Mass., is working on curriculum materials for elementary and junior high school science. With a grant from the National Science Foundation the center will continue work on a curriculum project begun more than a year ago with funds from the Sloan and Victoria Foundations. In its earlier efforts the project had created an embryology unit on the cellular nature of living things for the fifth grade. The unit uses some subject matter from biology to acquaint the pupil with problems and methods of science. It requires him to use laboratory equipment, three kinds of measurements, and quantitative representation in graphing results of elementary chemical analysis of cells. It encourages the pupil to design simple experiments, observe living things, come to a conclusion, and then test his conclusion by experiments.

During the 1961–62 academic year the project staff experimented with additional units, including one for the first and second grades in which pupils examine the behavior of fish by making observations and performing simple experiments.

Project plans for work during the summer called for 45 full-time and 43 part-time participants to work together with at least 5 persons from Africa. Before their meeting, the participants were given the guidelines growing out of the feasibility conferences sponsored by the American Association for the Advancement of Science (AAAS). After reviewing elementary school science activities and observing demonstration teaching, the participants were to decide what they would concentrate on, either as individuals or as teams. They would then develop ideas, prepare materials and plans, and try them out with elementary school children. Afterward they would review their materials and results, and in so doing prepare themselves for further revisions, reviews, and expanded trials. There appears to be no basic design for a frame of reference in the materials to be prepared.

THE American Association for the Advancement of Science has for some time maintained a center for development work in science education. In 1960 officials asked themselves whether it was feasible to undertake a major effort to develop science studies for children in elementary and junior high school. To learn the answer to their questions they had a feasibility study made. The 1961 report of the study—it was based on a series of papers and three regional conferences—made recommendations on eight points on which there was substantial agreement:

Science should be a basic part of general education for all elementary and junior high school pupils.

Instruction at the elementary level should deal in an organized way with science as a whole.

There must be a clear progression in the study from grade to grade.

There should be no single national curriculum.

Teaching should stress the spirit of discovery characteristic of science.

New instructional materials must be prepared for inservice and preservice programs for science teachers.

The preparation of instructional materials will require the combined efforts of scientists, classroom teachers, and specialists in learning and teacher preparation.

There is great urgency to get started on the preparation of improved instructional materials for science.

The report suggests the steps that should be followed in developing materials: (1) Identify major concepts, principles, and content areas to be covered and prepare a sequential plan for developing them; (2) collate research data on elementary and junior high school science instruction and define problems that need study; (3) prepare alternative blocks of material (texts, teachers' manuals, tests, and so on) for the several grades or content areas; (4) try out preliminary materials in the classroom, study criticisms and suggestions, and revise material; and (5) prepare sets of materials for general use.

With funds from the National Science Foundation the AAAS is now able to go on with the work that is feasible, establish a national commission on plans and materials for elementary and junior high school science, attempt to carry out the recommendations, and begin to prepare materials. In the summer (1962) AAAS also scheduled two 10-day study conferences to review the work others have done and to consider suggestions for what should be done. Apparently the project directors will try to use concepts and principles as a basis for arranging a science curriculum. Just what the project will produce is not clear but it promises, I believe, that the essence of science will be prominent in what is produced.

IN ALL these plans and studies we see some new ideas, some old. We see new leaders entering the field, schools showing a greater sense of responsibility for science curriculums and materials, scientists and teachers collaborating effectively. We see a reflection of the national interest in better education. The plans that have been made and those being made promise what may well be a brilliant metamorphosis in the development of science for young people.

# Changing directions in elementary and junior high school science

**Where are the curricular changes in science leading the elementary and junior high schools? Dr. Johnson puts his vision of the changes likely in the years ahead into "a few bold statements." These statements, summarized below, specify 14 changes—**

### 1. From much subject matter to less

Some general science teachers try to cover as many as 20 or 24 topics in a year; others settle for as few as 8 or 10. Some junior high schools spread the topics over a 3-year period (about 8 a year); others assign 12 topics to the grades 7 and 8 and 12 topics to grade 9; and still others adopt a spiral plan under which pupils study the same topics in grades 7 and 8 and again in grade 9 or later. This means that the number of topics can be reduced substantially. Some leaders believe that the elementary school teacher should teach only one or two topics; others, that an elementary or junior high school teacher should not teach topics at all. How the problem will be resolved remains to be seen.

### 2. From one problem-solving method to many relatively unstructured methods

Many persons, including some teachers, see problem solving in science as a clear set of steps leading from problem to evidence to conclusions; some add a phase called application; some have very clear ideas about how evidence should be gathered. Most of the persons who hold these views have had little experience with scientific research and know very little about how scientists go about finding and solving problems. In recent years some competent scientists have given of their time to helping young people come to understand science and scientists. Teachers who have studied their efforts are learning that scientists find problems in different ways and approach answers in many ways. Now it is coming to be generally recognized that the best way to help young people understand science is to help them to find problems and to seek answers to them rather than tell them how scientists do it.

### 3. From much use of one book in a series to the use of many books

Because the majority of science teachers in elementary and junior high schools have had little preparation in the sciences, they have come to accept the adopted textbook as their guide. Furthermore many of them have limited library facilities and little time to learn about materials available. Recently scientists identified good science reference books for precollege levels. After such books had been assembled in sets, circulated among schools, and the results of their availability studied, the lists were improved. Since then some schools have bought a recommended set; others are beginning to buy. With good reference materials available, with home and school encouraging wider reading, and with science fairs and exhibits encouraging pupils and teachers to go to references, there will be more and more use of books other than textbooks.

### 4. From emphasis on accumulating knowledge to an emphasis on how to find and create knowledge

The kinds of tests that teachers have used over the years indicate the emphasis in science classes: getting the right answer to a question was the goal, for the answer determined the grade. It was just too bad for a pupil who made an error in one operation even though he used the correct method. Gradually partial credit for the correct method became acceptable, and more recently tests have included the information the pupil needed to answer questions and the pupil has been tested on his ability to interpret or use the information correctly. Now tests are available that require much thinking and reasoning ability, but little recall. We can expect to see more and better tests that measure the pupil's ability to think as scientists think.

### 5. From facts and factual concepts to skills in inquiry as teaching goals

An increasing number of study guides are beginning with activities designed to raise questions or problems in pupils' minds. Pupils are encouraged to propose hypotheses on a problem and then gather data from experiments to support or refute them. These guides usually suggest experiments, but pupils are being encouraged more and more to design experiments that may produce evidence, to consult reference books, to interview people who know something about the subject they are studying, and then to restate their hypotheses and use them to explain phenomena. Study guides recently developed by expert scientists make the spirit of inquiry the major goal; concepts still rank high as goals but are not listed and are therefore not likely to be taught as such. Pupils will develop concepts naturally through the process of inquiry. This change is just in the beginning stage.

### 6. From teacher selected concepts as teaching goals to concepts as they arise in confirming and rejecting hypotheses

Most textbooks do little to encourage pupils to state their own hypotheses, seek confirmation or rejection, and form their own concepts—a practice some leaders are encouraging teachers to follow. Stress on the processes of inquiry seems to promise more and more encouragement for this type of teaching.

### 7. From the terms "elementary science" and "general science" to "science"

It is the spirit or essence of a study that counts, not the title given to it. Even so, it is becoming common to refer to science studies in elementary school as *science—grade I, science—grade II,* and so on. The stress on the processes that scientists use in their work reflects the belief that studies should be real science rather than about science. If the studies are real, the qualifiers "elementary" and "general" are not appropriate.

### 8. From reliance on qualitative observation to stress on making and recording quantitative observations

The influence of scientists and the movements to make mathematics more meaningful to pupils have led to stress on quantitative measurements. Models, graphs, tables, and new symbols are being used to help pupils understand relationships. Scientists have encouraged the use of available measuring devices and have searched for inexpensive and simple ways to make accurate measurements. We can expect this change to continue.

### 9. From films that stress a body of knowledge to films that report one or a series of experiments

Until recently it often seemed as if film producers had tried to see how much they could put into an 11-minute film. Now, however, some of the new films present a scientist (not an actor) conducting a great experiment and reporting it on film and in spoken words. Some of the experiments are presented so carefully that pupils can make and record their own qualitative and quantitative observations. Other films show great scientists explaining and illustrating their work to visitors. We can expect an increasing number of such films to be produced and made available to schools.

### 10. From science experiences as preparation for secondary school science to experiences for the basic education of all pupils

Few people question the need for a scientifically literate citizenry, and school leaders with no organized science program are looking for ways to include science courses. This change is definite but how best to guide it is open to disagreement; however, scientists working with other knowledgeable people are certain to find acceptable ways.

### 11. From science as something to be learned from books to something that grows out of a series of experiments

Although teachers find experiments useful and pupils find them interesting the first time they see or try them, something besides experiments seems necessary to a science program. The change toward grade placement of experiments within a larger framework promises to continue.

### 12. From a program based on topics, limited concepts, and experiments to one based on a more fundamental frame of reference

Outstanding scientists interested in science programs for elementary and junior high schools say that covering science topics and doing experiments are not science. They speak of pupils discovering concepts and of helping pupils interpret natural phenomena, understand science, learn the ways of scientists, and become effective inquirers. They say that the scope and sequence of science work must be planned, yet they have no clear word on how plans should be made. They deplore teaching topics, yet in their own courses for teachers they teach topic after topic. The great efforts now being made to formulate strong science programs for elementary and junior high schools will give rise to different frames of reference that will present improved views of the scope and sequence of science programs.

### 13. From great attention to uses of science including technology to more attention to science

Courses in general science, many leaders say, have given too much attention to technology; the search for fundamental principles of science and efforts to understand them through experiments and demonstrations have been set aside in favor of reading about technological developments. Just how general science courses can be made to reveal science and scientists in proper balance is not yet known. Nor is it known how much attention can and should be given to technological developments. Studies now being made promise to consider such problems.

### 14. From science built on a limited understanding of mathematics to science built on mathematics

Many leaders believe that there is a growing kinship between science and mathematics instruction, that persons in each discipline are responsible for advancing the frontiers in their fields, that advancement in one field conditions to a great extent advances in the other. There should be, they say, a close working relationship not only between leaders in these two disciplines but also between them and leaders in liberal and fine arts. Perhaps mathematics and science teachers are working more closely together even if the change is not now clearly visible.

JOHN H. WOODBURN

# *The first problem: Helping the teacher*

HOW CAN TEACHERS be helped to construct and administer science curriculums that actually involve students in science, that actually launch students on their own pursuit of science? To me, this question states what is, by far, the most important problem of supervision in science. This is my answer.

Help your teachers to really comprehe the spirit, structure, and function of science. Back up the training they have in the facts, laws, and principles of science with readings in the history, philosophy, and logic of science. Encourage them to examine the original writings of the world's great scientists, living and dead, not only to see what these men have done, but also to recognize the personal traits and characteristics that recur among them. Insist that their cultivating these traits in their students is a vital part of the teachers' responsibility. Recommend that daily assignments place great emphasis on science as a human endeavor, as one of the things men and women do, as something more than adequate to capture the mind, heart, and soul of men and women. Put them in touch with good biographies of great scientists.

Elevate to a level of supreme importance the analysis of the powers of the mind that are exercised in the discovery of facts, laws, and principles. Let us stop taking refuge behind the apology that the methods of science are difficult to describe, that some vague principle of indeterminancy shields the scientist from both introspective and overt efforts to describe his method of attacking problems. It is true that we may never have a formula whereby success in science can be punched into a computer, but we do know that there are some things which separate the men from the boys in the pursuit of science. We all know, for example, that the scientist must be able to exercise a ready and faithful memory, to detect resemblances and differences, to compare, to communicate, and to discipline his mind to stay with a problem long after fatigue has begun to gnaw at his faith that the problem will be solved. It is only failure to attempt to exercise the minds of our students that calls for apology.

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It may be naive to say there is a pattern in the way scientists go about their work. Perhaps the stereotyped idea—the idea that they identify a problem, elaborate a hypotheses, and design, conduct, and evaluate an experiment—is only a superficial description. But is there a more logical frame of reference to use in the analysis of episodes in science? Where can we turn for a better design for our lessons? No better lesson happens in my classroom than on those all too rare occasions when I can actually confront my students with a puzzling circumstance—puzzling because they see something contrary to what their previous experience had led them to expect—and then to help them to see in the circumstance a clue to the operation of a law or principle that would, to quote Albert Einstein, "make the chaotic diversity of our sense experience correspond to a logically uniform system of thought." On those days when things really go well in my classroom or laboratory, we find ourselves with several logical hypotheses, each promising to explain a puzzling observation, and there is nothing to do but design and conduct experiments from which to obtain a basis for embracing one hypothesis and rejecting the others.

Such lessons do not put students to sleep or invite competing discussions of last night's ball game. They do not glaze the eyes of boys and girls fed up with memorizing barebone facts they have been told they must know to pass college board examinations. Nor do such lessons require a hell's-a-poppin' demonstration.

Help your teachers to dabble in science. Lead, coax, or inspire them to carry on small-scale experiments on their own. Tell them the school's laboratories are their laboratories, that they are welcome to use the equipment and reagents, the reference books and supplies ordinarily requisitioned for students. Encourage them to requisition apparatus and supplies needed solely for their own research. Take pride in what they do, and share their enthusiasm.

Encourage your teachers to shepherd their students on small-scale excursions in the pursuit of science. If you feel that changes in education must come slowly, let them begin innovations with superior students for whom the usual class routine may be unnecessary. Build into your teachers' daily schedules a few minutes when they can help students shape individual problems, dream up hypotheses, and design and conduct experiments with some chance of yielding worthwhile data.

Use your resources to develop courses of study in which there is a maximum number of whole and entire episodes in science—episodes which confront students with all of the essential features of science. Make sure each episode begins with the events and circumstances that bring a phenomenon into the classroom in a way that is consistent with the way it originally caught the imagination of scientists. Build into these episodes the stuff students need to create hypotheses—many hypotheses—and conduct experiments—many experiments. Select from the storehouse of science those episodes which show most effectively the characteristics of scientists, the creation of their hypotheses, and the design of experiments to test hypotheses. Select episodes which, through analysis, reveal the powers of the mind that are exercised in the pursuit of science. Weave from selected episodes a course of study that will introduce the student to the things which motivate the scientist, that draw from him the intellectual performance necessary to pursue science, and give him the satisfactions that come from the discoveries and inventions that are its products. Let the processes of science be the target for your courses of study. To hit this target, you will, of course, need to include more of the produce of science, its facts, laws, and principles.

The time is ripe for you to go all-out in helping your teachers to teach in the true spirit of science, consistent with its methods, and complementary to its functions. Students will respond to the intense motivation inherent in the pursuit of science. They will enjoy exercising their minds. The experience they gain will insure that the scientific endeavor will continue to be staffed with young men and women who are more than capable of continuing the advance of science and the improvement of our civilization. It is for you to give the leadership. This you can do. Things are building up on your side. Textbooks are becoming available that must be literally millions of dollars better than those they are to replace. You have in your school systems and in nearly all of your faculties teachers with the benefits of one or more summer or academic-year institutes. Surely these and other gifted people staffing so many of the projects to improve the teaching of science should be able to give you the help you need.

You know the conditions which exist in our classrooms. You know where the bottlenecks are. You have been involved in the evolution of the psychology of learning. You understand who our students are. No one is in a better position to pull together the assets of the past and combine them with the resources of the present to give our teachers leadership. I know of no better way of improving science teaching than for supervisors to help science teachers to teach in the true spirit of science, consistent with its methods, and complementary to its functions.

## A Science Teacher's Hope

I hope someday to be able to teach science much as my friends across the hall teach art.

In the art department each day's lesson is a small-scale excursion into a human endeavor. The teachers encourage each student to start with whatever proficiency he has and to improve this proficiency in one way or another. During the lesson they show the students copies of masterpieces or lesser works so that each student may analyze in detail the processes peculiar to the artist. Quite often the teachers discuss the culture in which an artist lived and worked so that the student may contrast his own environment with that in which great art seems to evolve. At times, the teachers encourage each student to produce disciplined exercises—to do the same thing over and over until he has achieved a degree of skill that enables him to pursue his own artistic expression. As I observe students studying art I feel that even the least fitted boy or girl is catching the spirit of art, that each is exercising his mind and hands in the things artists do, and that his accomplishments are directly comparable to the function of art in our society.

To understand what I mean, observe one of the science teachers with whom you are associated with these questions in mind:

Does he really comprehend the spirit, structure, methods, and functions of science?

Is he developing with his students the characteristics which recur repeatedly in the personalities of practicing scientists?

Is he exercising in his students the powers of mind that are essential to the pursuit of science?

To motivate his students, does he use the things that motivate scientists?

Does his lesson plan parallel the methods scientists use to pursue their investigations?

Is each lesson directly traceable to a puzzling event or circumstances that demands explanation or description?

Does he help his students to elaborate hypotheses on a phenomenon and to gather data for testing them for logical consistency? To design experiments to test these hypotheses? To examine conclusions so that they may plan more efficient investigations?

Does he take time to examine with his students the effect of a newly formulated principle or an ingenious invention on the beliefs and behavior of people?

—JOHN H. WOODBURN

J. Darrell Barnard

# *Improving science education*

MORE MAN-HOURS have gone into projects to improve science education in the past 10 years than in any 50 years in our history. The primary motivation for such a phenomenal effort is to increase the quantity and quality of our scientific manpower. Although the evidence is substantial that this effort is beginning to pay off, the task is far from done—if it will ever be. Because of the multiple variables in the educational process, we will never completely solve the problem of improving educational practice. To complicate the problem further, these variables interact between two dynamic enterprises—science and a free society. We must not complacently assume that new science courses and intensive effort to improve the science teacher's background have raised or will raise science teaching to the level we want. Science teaching will improve only as we persistently work at improving it. There will never come a time when we can say "the job is done."

Before anything of significance will come from a commitment to the principle that curriculums must be *sequential* and *developmental* from the elementary school through the secondary school, for all students, we must look hard at our points of view toward *objectives*, the *learning process*, and *evaluation in science teaching*.

We have developed a laissez-faire attitude toward certain practices which we, as educational leaders, should vigorously challenge. The most critical of these practices is the manner in which curriculum workers, course-of-study makers, and teachers have dealt with the objectives of science teaching. Nearly every curriculum or course of study has a well-formulated list of objectives in its preamble reflecting the objectives that have appeared in professional literature for 30 years. Yet many who develop these courses have little intention of letting objectives get in the way of developing a course or curriculum according to conventional patterns. Nor do curriculum makers seem to have much predisposition to follow through with teachers to make certain that they understand the objectives and reflect them in teaching.

"Critical thinking" and "understanding of basic concepts" are objectives common to these lists. Yet in some courses, the range of content is such that to cover it and develop reasonable understanding is impossible and the suggested learning activities do not clearly identify "critical thinking" as an outcome. Moreover, investigators such as Beauchamp, Obourn, and Powers have found that teachers either do not accept these objectives or do not comprehend them—and, consequently, do not provide for them in teaching.[1] Too many educators view the learning process as only a matter of filling the mind with facts, a no longer tenable idea. Their attitude toward evaluation is no better. As long as they judge achievement in science learning primarily by verbalization of definitions and factual material, discussion of or planning for more significant objectives will be largely a waste of time and effort.

A good science program gives the student an understanding of basic concepts and the processes of science or methods of critical thinking, and through it he learns that concept and process are inextricably related. It teaches him that scientific concepts are not made known by supernatural authority but are wrested from nature through the persistent application of man's intelligence.

Insofar as the concept-process purposes relate to teaching and learning science, correspondence with the scientific enterprise is striking. Research on learning shows clearly that no one can give another person an idea—a concept. He must think his way to it. It is his when it becomes part of his conceptual schemes and patterns through a critical thinking process. He learns by getting meaning out of what he is taught, and meaning develops from experiences that involve him in critical thinking.

Powers found that chemistry students can verbalize concepts without understanding them. He found that a relatively small proportion of the good verbalizers understood chemistry as it was conventionally taught. His research seems to indicate that much of what has gone on

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[1] Wilbur L. Beauchamp, Instruction in Science, U.S. Office of Education, Bulletin No. 17 (Monograph No. 22), Washington, Government Printing Office, 1932. 63 pp. Ellsworth S. Obourn, Assumptions in Ninth Grade General Science, unpublished doctoral dissertation, New York University, 1950. S. R. Powers, "The Correlation Between Measures of Mental Ability and Measures of Achievement in Chemistry," *School Science and Mathematics*, 28 (December 1928), pp. 981–986.

in science classes has been a tragic waste of time and effort.[2] Tyler found that science students taught with emphasis on verbalism in 1 year forgot about 80 percent of what they had learned. On the other hand, he found that the retention curve of students taught to think their way to an understanding of selected principles of science went up during the year after completion of the course.[3]

If we specialists in science education believe that decisions about what to teach in science and how to teach it should be based on experimental evidence, then we are morally committed to work for a major reconstruction of science curriculums and drastic reorientation of classroom practices. If we take the evidence seriously, we will make radical changes in science teaching.

We need to reconsider the objectives of science teaching in terms of their validity and the methods by which they may be applied more effectively in helping students to acquire a better understanding of the basic concepts of science. We need to reexamine the conceptual structure of science and to identify the basic concepts. We need to design and use evaluation instruments that measure achievement in understanding science concepts and in using the processes of scientific thinking. We need to be more concerned about the way in which young people are going to be different because of their experiences with the science curriculum we build. Through these experiences they should attain not only a better comprehension of the conceptual schemes that explain natural phenomena, but a better understanding of how these concepts affect the personal, social, economic, and political lives of people. They should develop not only a better understanding of the processes of inquiry as used by scientists, but greater competence in using the processes and, consequently, in becoming more self-directive in their learning. We should motivate more of them than we do to sustain intellectual interests after formal schooling is completed. It is imperative that science—and other subjects—in our schools fulfill the demand of a free society for citizens who possess the essential skills and motivation to continue their intellectual development. Our progress toward this goal as a central purpose of education has been less clearly demonstrated than has our progress toward meeting the needs for scientific manpower.

I recommend the reexamination of the points of view and recommendations of such science improvement projects as those of the Bureau of Educational Research in Science and the 8-Year Study. These projects were more clearly directed toward the personal-social meaning of science than appears to be the case in most of the current science improvement projects. The earlier projects sought ways in which science could be used to change the behavior of young people in personally satisfying and socially desirable ways and were concerned with the scientific literacy of all young people.

Of recent projects to improve science teaching, the best known are being conducted at the University of Illinois, University of California (Berkeley), University of Colorado (Biological Science Curriculum Study), Harvey Mudd College (Chemical Education Material Study), Earlham College (Chemical Bond Approach Project), and Educational Services, Inc. (Physical Science Study Committee). The first two projects are on elementary science; the last four on secondary school science. The elementary studies were motivated by the feeling that present courses of study, textbooks, and other materials in elementary science do not adequately reveal the methods and goals of basic science. The secondary school studies have sprung from concern over the fragmentary, descriptive, and technological nature of the conventional high school courses in biology, chemistry, and physics. The studies are designed to reduce each science to its basic structural concepts and to develop materials for teachers and students.

These projects represent breakthroughs in the development of materials and courses. Rather than merely revising present courses or working over classical learning activities, each project is taking a fresh look at what should be taught and how it should be taught from a scientist's point of view. Rather than merely developing point-of-view statements, lists of objectives, and generalized guidelines for curriculum workers and teachers, each project is developing specific learning experiences for teachers to use with students. Rather than assuming that these learning experiences are suitable, the projects have extensive programs for trying them out and using the evidence obtained as bases for revisions. Rather than assuming that the dated and variable subject-matter preparation of teachers and the teaching methods which they learned can see them through new courses, the projects are developing intensive programs for the reeducation of teachers.

These projects also represent other worthy breakthroughs. To the fact-happy, ground-covering teacher and test maker they clearly demonstrate the significance of science facts and major scientific concepts in teaching for understanding and of pupil participation in processes leading to concept formation and an understanding of the methods of scientific inquiry.

[2] S. R. Powers, "The Correlation Between Measures of Mental Ability and Measures of Achievement in Chemistry," *School Science and Mathematics*, 28 (December 1928), pp. 981–986.

[3] Ralph W. Tyler, "What High School Pupils Forget," Ohio State University, *Education Research Bulletin* 9 (November 19, 1930), pp. 490–492.

I am, however, concerned about three matters connected with these projects: Their exclusive commitment to basic science; the extent to which the new secondary school courses are adaptable to the ability, interests, and needs of all high school students; and how the results will be incorporated into a K–12 development sequence.

Many proponents of the projects are more strongly antitechnology than probasic in their passion to be "pure," perhaps as a natural reaction to science courses that had become almost exclusively applied science, in both elementary and secondary schools. My thinking about science teaching has been stimulated and challenged by these reactionary or radical purists, and I'm not about to write them off. Neither am I about to write off a belief that science should make a difference in the lives of young people; nor the convincing evidence that the manmade environment of spaceships is in many ways more challenging to young people than phenomena categorized as natural environment. To teach science unrelated to or insulated from the lives of young people would leave much to be desired. But to deal with science only from a consumer's point of view would be equally disastrous. We must have both—pure and applied. We should not, however, give the impression that technology and science are synonymous.

The answer to the question of the extent to which the new secondary courses are adaptable to the ability, interests, and needs of all students should be coming through soon from field tests in schools.

There are many unanswered questions on what should be the nature of science courses for the student who is not planning a career in science. Some of us foolishly assumed we had the answers 30 years ago. I hope those working on the answers now will not make the same assumption.

Neither of the two elementary science projects I have mentioned have developed an overall elementary science curriculum. The materials they have developed, however, are being tried at several grade levels to determine grade placement. None of the new high school science courses has been conceived within a developmental sequence. Nor has there been a major study of what the nature of the sequence should be in junior high school.

Several proposals for studies of sequence have been made. Studies on sequence will be charting relatively unexplored territory. It is probable they will chart several routes. It is important that a clearly defined purpose be identified and that plans be made early in the studies to evaluate relative progress toward their achievement.

We have reached the place where the "cut-and-fit" method of curriculum development in science needs a pattern to follow. We need to design and try out several K–12 curriculum patterns so that the old patterns and the new ones can be fitted into a rational whole. Some may believe that the basic design should be uniform for all schools. Others may contend that a minimum uniform basic design should be developed, one that local communities and the States can modify as they see fit. Still others believe that several "good" patterns should be developed and tested and their relative success evaluated. On such evidence, schools could adopt whichever pattern best fits their needs. It is imperative that we develop some rational designs and test them under conditions which permit objective comparisons.

## Science for Every Man

***Every man, scientist or not, needs scientific knowledge.*** This idea was expressed many times and in many ways during the State science supervisors' conference. Dr. Trytten, for example, asked educators to consider science for every student as one of their main objectives (see p. 7). And Dr. Barnard, Dr. Glass, and Dr. Stephenson also emphasized the idea. They said—

J. Darrell Barnard: Although the primary goal of our all-out effort to improve science education has been to educate scientists, we must not lose sight of the students who will not become scientists but must live with science—those who will become lawyers, clergymen, housewives, farmers, truckdrivers, and merchants. They will be seeking to live satisfying lives in a society increasingly influenced by science. But they will make decisions that will indirectly affect it. *Science must become an integral part of the education of all from the elementary school through college.*

H. Bentley Glass: For a scientific society to be democratic, the people themselves must understand the nature of the scientific forces and problems that dominate their lives. The general citizen of this country, the man in the street, must learn what science truly is, and not just what science can bring about. If he fails to learn, then within a brief period of years we may expect either nuclear devastation or worldwide tyranny. It is not safe for apes to play with atoms. Neither can men who have relinquished their birthright of scientific knowledge expect to rule themselves.

Robert C. Stephenson: If future generations are to deal intelligently with such broad social and economic problems as increasing population, rising standards of living, and dwindling nonrenewable resources, they must have a basic scientific understanding of their physical and biological environment.

**A small group at work at the Office of Education conference for science consultants in State departments of education. When the National Defense Education Act was passed, in 1958, only 8 States had a full-time consultant for science; today nearly every State has at least one consultant for science or for science and mathematics together.**

Those of you who have built curriculums know what an accomplishment it is to get ideas on paper. Consider how difficult the job becomes when teachers must be persuaded to try a new curriculum and submit reactions. It will be a monumental undertaking to develop evaluation instruments and design a study to determine objectively the relative success of several K–12 curriculum patterns, but it must be done before we can make defensible decisions based on experimental evidence.

The great national interest in science and the improvement of our scientific effort has two primary implications for us: To get on with the job of building K–12 science curriculums with scientifically rational sequences that are developmental in terms of concepts and process goals and are based on the needs, interests, and abilities of all students at each grade level; and to prepare teachers to do the job demanded by the new curriculums.

The preparation of science teachers begins in the high school with science teachers who zealously recruit their best students for science teaching. It continues in college, where the convert's zeal is fed and fanned by experiences tailormade for the future science teacher. It continues once he is teaching—both the college and the school must work together to help the teacher continue his education.

Hurd is highly critical of the conglomerate college programs of science study for science teachers and questions the effectiveness of general courses in methods of teaching as preparation for science teaching. He recommends that colleges wanting to improve their science teacher education programs follow, as a beginning point, the eight guidelines set forth in the joint report of the American Association for the Advancement of Science and the National Association of State Directors of Teacher Education and Certification.[4]

Until colleges and universities redesign or overhaul their teacher education programs, science teachers will need inservice education. The inservice preparation of teachers is a major part of the course improvement projects I have mentioned. To date, institutes sponsored by the National Science Foundation to upgrade and update the science backgrounds of teachers have enrolled more than 30,000 science teachers. Many teachers have attended several institutes. There is little question that these institutes have an influence on science teaching, but the extent of the influence is yet to be evaluated.

Gruber, from a study of 55 high school science and mathematics teachers who attended an academic year institute at the University of Colorado, found that the program's main weakness is that it transmits attitudes and information relevant to teaching science as a body of knowledge, not as a way of thinking.[5]

The planning of institutes for science teachers has largely been the responsibility of college scientists who have planned on limited knowledge of what high school science teachers need. It seems to me that it would be more appropriate for people from the schools and the colleges to plan institutes cooperatively. The effectiveness of the institutes thus developed could be evaluated in terms of measured changes that take place in the schools. I believe that a cooperative attack on the problem at the State level would pay high dividends.

The problems involved in the improvement of science teaching are numerous, as are the variables involved in their solution. The success of this conference will be determined by the extent to which it will help each of us to more clearly define the problems, establish priorities, and point the way to promising solutions.

[4] Paul DeH. Hurd, "The Education of Secondary School Biology Teachers," *BSCS Newsletter 13*, Biological Science Curriculum Study, University of Colorado, Boulder, May 1962, pp. 7–10.

[5] Howard E. Gruber, "Science Teachers and the Scientific Attitude: An Appraisal of an Academic Year Institute," *Science* 132 (19 August 1960), pp. 467–468.

# AD Minutes Briefly noted--- for the busy School Administrator

*Material for this department is prepared by the staff of the School Administration Branch, Division of State and Local School Systems*

**The U.S. Supreme Court** has agreed to review three cases which have special meaning for educators. In two, church-State relations are at issue: No. 119, *Murray* v. *Curlett,* and No. 142, *Abington Township School District* v. *Schempp,* are concerned with the constitutionality of Bible reading and the Lord's Prayer recitation in the public schools. The other case concerns public school integration plans and what constitutes *de facto* and *de jure* racial segregation: No. 217, *Goss* v. *Knoxville Board of Education.*

**Prefabricated portable classrooms** are under construction for use at three "pilot" schools in New York City to relieve serious overcrowding. Many other schools will receive portables, but the board of education has emphasized that no program will be announced until the practicability of the pilot units has been determined. The portables under study, made of aluminum sections resting on concrete platforms, can be demounted and rebuilt on other sites.

**A new type of countywide** intermediate administrative structure servicing minimum-sized local districts of 2,000 pupils was recently recommended for the St. Louis metropolitan area by a University of Chicago survey staff that had examined and rejected a number of other proposals for improving district organization. A fiscally independent coordinating unit, designed to supplement and strengthen local district programs, was recommended by the survey staff as one that preserves the principle of local decisionmaking and at the same time insures countywide planning and support.

**Multiphased high school schedules** have been established in the Melbourne High School (Fla.) Each course is identified by a phase number rather than by grade level: Phase 1 is remedial work; phase 2, basic skills; phase 3, average education; and phase 4, education in depth. Courses labeled phase 5 are open only to students "who are willing to assume responsibility for their own learning and plan to go far beyond the boundaries of a single course." Advocates say that the system makes individual instruction possible.

**A poor neighborhood** in New York City will serve as a laboratory for an experimental program dealing with the problem of juvenile delinquency. The research design, prepared by Mobilization for Youth, Inc., a nonprofit corporation, includes plans for an intensive home-visiting schedule for teachers. Purpose of the visits: To assist teachers in learning about the effect of home environment on school performance and to overcome the parents' feelings of suspicion and fear toward the school.

**Teachers' salary schedules** in Southern California are being reevaluated by a new method. Each schedule gets 10 tests, 1 for each of 10 common features of salary schedules, such as minimums, maximums, and number of steps. Each of the 10 tests is scored between 1 and 100, making possible a total score of 1,000. Thus far, 2,900 tests have been applied to 290 schedules; and 166, or 5.7 percent, have turned up scores of 100. This attempt to evaluate schedules objectively is sponsored by the California Teachers Association—Southern Section.

**One out of 10 teachers** in South Carolina left his position in 1959–60. Typically, those teachers were among the least experienced and were replaced by others who also had little, if any, experience. Staff members of the University of South Carolina who uncovered these facts in a survey made for the State department of education call attention to the fact that, although salaries of teachers in the State have increased in the past decade, the major proportion of funds has generally gone to raising salaries of beginning teachers. The study questions the practice inasmuch as it rewards teachers who will teach only a few years and limits the increases to "teachers who actually make a career of teaching and add stability, continuity, and accumulated skills to the schools in which they are employed."

**Information on fall school membership**—how to make it both reliable and promptly available: This was the subject discussed by educational consultants at a conference held by the Midwest Research Institute in Kansas City, last summer to consider the larger subject of county population estimates. Six States were represented: Arkansas, Iowa, Kansas, Missouri, Nebraska, and Oklahoma. Participants included representatives from State departments of education and the nonpublic schools, economists, census experts, and a specialist from the Office of Education to advise on the use of standard terminology in collecting information about pupils. The institute, a nonprofit scientific organization that assists industry, agricultural groups, and educational institutions in the 6 States, has completed 2,500 research projects for 950 sponsors since 1945.

# SCHOOL BONDS—

**Sales, Interest Rates, et cetera**

*A monthly report by* ELMER C. DEERING, *Office of Education specialist on the financing of school facilities.*

IN MOST RESPECTS the first 6 months of 1962 made a better record in school bond sales than the same months in 1961.

One point in 1962's favor was that sales were larger. Total sales for the first 6 months exceeded $1.7 billion—13 percent over the $1.5 billion for the same period in 1961. Sales of Moody-rated bonds increased by 10 percent.

Another improvement was that a larger percentage of the bonds sold were top quality (Aaa) and a smaller percentage were low quality (Ba). But this gain was obscured by what happened in the next-to-the-highest and the next-to-the-lowest ratings; in the end, bonds with the two highest ratings, taken together, constituted only 29.3 percent of the sales compared to 36.7 percent in 1961; and bonds with the two lowest ratings constituted 26.1 percent compared to only 22.9 percent in 1961. In each of the two half-years the amount sold at each rating was as follows:

| Moody rating | January–June 1961 | | January–June 1962 | |
|---|---|---|---|---|
| | Amount sold | Percent of total | Amount sold | Percent of total |
| Aaa | $20,752 | 2.0 | $41,018 | 3.5 |
| Aa | 368,362 | 34.7 | 302,030 | 25.8 |
| A | 429,581 | 40.4 | 522,255 | 44.6 |
| Baa | 209,967 | 19.8 | 280,731 | 24.0 |
| Ba | 33,126 | 3.1 | 23,914 | 2.1 |
| Total | 1,061,788 | 100.0 | 1,169,948 | 100.0 |

The most significant change in 1962 was the decrease in interest rates. For all Moody-rated bonds except the Ba, the average net interest cost was lower than in 1961:

| *Moody rating* | *January–June 1961 (Percent)* | *January–June 1962 (Percent)* |
|---|---|---|
| Aaa | 2.90 | 2.74 |
| Aa | 3.36 | 3.02 |
| A | 3.37 | 3.07 |
| Baa | 3.67 | 3.41 |
| Ba | 3.85 | 3.86 |
| All ratings | 3.43 | 3.14 |

The difference of 29 basis points between the overall average in 1962 and the average in 1961 means an annual saving of more than $3 million in interest payments on bonds sold between January and June 1962.

A major factor in the decline in interest rates in 1962 was that in December 1961 the Federal Reserve Board, in a supplement to its Regulation Q, permitted banks to pay higher rates on time deposits. During the first 3 months of 1962, according to the July 1962 *Federal Reserve Bulletin* (pp. 791–795), time deposits of all commercial banks increased $5.6 billion, "at an annual rate of 25 percent, faster than in any other postwar period. . . . Bank emphasis on longer-term investments—associated with the large increase in time and savings deposits—was reflected mainly in unusually large purchases of State and local government securities. . . . As bank demands for these securities expanded in early 1962, their yields declined sharply, falling about 35 basis points in 4 months to a low of 2.92 percent of Aaa-rated issues in early May."

Average monthly interest costs for all Moody-rated bonds reached a low in April 1962 and then turned upward (see table below). Municipal bonds, which include school bonds, followed the same pattern except that they did not reach their lowest point until a month later. The low in April for school bonds was due mainly to 6 large sales—40 percent of the total—at very low rates (*School Life*, June 1962, p. 25). Had it not been for these sales, the April rate for school bonds would have been 3.14 percent and school bond rates would not have hit their low point until May, along with rates for other municipals. Although school bond sales are averaging more than $200 million a month (Moody-rated bonds, $150 million), unusual circumstances can cause extreme fluctuations. Fluctuations are to be expected, but it is necessary to know what lies behind them.

Average net interest cost of Moody-rated bonds sold on the primary market for public school purposes, August 1961–August 1962, by rating

| Period | Aaa | Aa | A | Baa | Ba | All rated bonds |
|---|---|---|---|---|---|---|
| 1959–60 | 3.26 | 3.63 | 3.77 | 4.21 | 4.55 | 3.84 |
| 1960–61 | 2.82 | 3.34 | 3.43 | 3.75 | 3.97 | 3.48 |
| 1961–62 | 2.84 | 3.23 | 3.19 | 3.52 | 3.93 | 3.27 |
| 1961: | | | | | | |
| September | 3.08 | 3.25 | 3.52 | 3.75 | ..... | 3.51 |
| October | ..... | 3.39 | 3.29 | 3.70 | 4.17 | 3.45 |
| November | ..... | 3.16 | 3.39 | 3.74 | 3.89 | 3.43 |
| December | 2.97 | 3.25 | 3.37 | 3.76 | 4.15 | 3.40 |
| 1962: | | | | | | |
| January | 3.02 | 3.13 | 3.21 | 3.54 | ..... | 3.23 |
| February | 2.75 | 3.00 | 3.14 | 3.39 | 3.93 | 3.13 |
| March | 2.80 | 2.99 | 3.07 | 3.34 | 3.89 | 3.21 |
| April | 2.56 | 2.84 | 2.85 | 3.35 | 3.61 | 2.94 |
| May | 2.56 | 2.95 | 3.02 | 3.34 | 3.80 | 3.13 |
| June | 2.82 | 2.83 | 3.14 | 3.48 | 3.93 | 3.21 |
| July | ..... | 3.15 | 3.13 | 3.61 | 4.02 | 3.22 |
| August | ..... | 3.03 | 3.08 | 3.43 | 3.82 | 3.18 |
| September | ..... | 2.80 | 3.08 | 3.48 | 3.75 | 3.11 |

Source: Sales reported by the Investment Bankers Association and The Daily Bond Buyer, which include about 75–80 percent of the total for public school purposes.

*Statistic of the Month*

# Foreign students in the U.S., 1961–62

EVERY YEAR BRINGS another increase in the number of foreign students enrolled in our colleges and universities. This year, in all likelihood, the total will reach a new high. Last year it was 58,086.

Where did the 58,086 come from? They came from 149 countries in all parts of the world, but more than half came from the East—Near, Middle, and Far. Over the years the proportion from the East has been rising even more steadily than the total number of students, as the chart and the table opposite show.

What did they study? The largest number, 22.4 percent of the total, were enrolled in engineering; the next largest, 19.2 percent, in the humanities. In each field the number enrolled at each level was as follows:

| | |
|---|---|
| Engineering | 13,031 |
| Undergraduate | 8,311 |
| Graduate | 4,210 |
| Special [1] | 510 |
| Humanities | 11,163 |
| Undergraduate | 6,259 |
| Graduate | 3,767 |
| Special [1] | 1,137 |
| Natural and physical sciences | 9,414 |
| Undergraduate | 3,334 |
| Graduate | 5,718 |
| Special [1] | 362 |
| Social sciences | 8,443 |
| Undergraduate | 3,351 |
| Graduate | 4,529 |
| Special [1] | 563 |
| Business administration | 5,085 |
| Undergraduate | 3,034 |
| Graduate | 1,684 |
| Special [1] | 367 |
| Medicine | 4,109 |
| Undergraduate | 2,009 |
| Graduate | 1,814 |
| Special [1] | 286 |
| Education | 3,042 |
| Undergraduate | 1,470 |
| Graduate | 1,273 |
| Special [1] | 299 |
| Agriculture | 1,893 |
| Undergraduate | 724 |
| Graduate | 1,062 |
| Special [1] | 107 |
| Other and unknown | 1,906 |

Who supported them? Thirty percent supported themselves. Thirty-eight percent were supported by private organizations; 9 percent, by the U.S. Government; 5 percent, by foreign governments; and 3 percent, by governments in combination with private organizations. Fifteen percent did not report source of support.

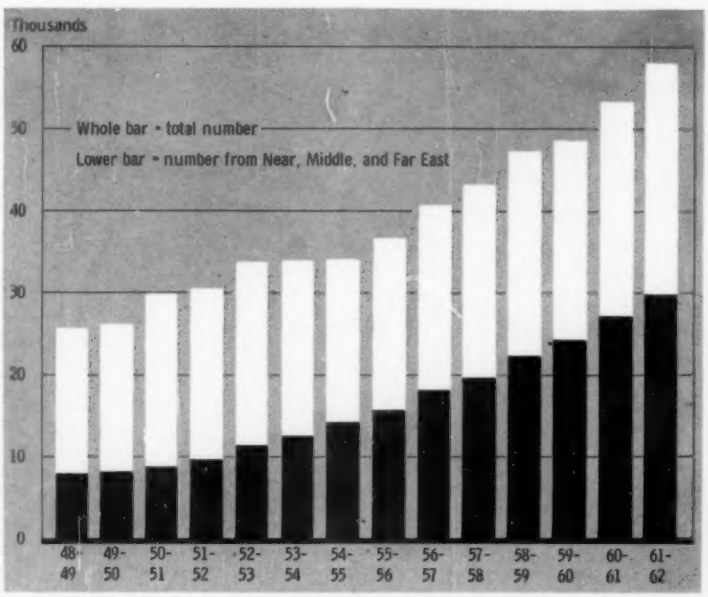
All the data on this page are from the Institute of International Education, 800 Second Avenue, New York 17, N.Y., which every year reports on foreign citizens in the United States on educational assignment, and on U.S. students and scholars abroad on similar assignments. The data for 1961–62 are from its latest report, Open Doors 1962.—Rose Marie Walker, educational statistician, Office of Education.

[1] Includes students not reported by level.

## Number of foreign students in U.S. institutions of higher education, by areas of origin, academic years 1948–49 to 1961–62

| Year | Total number | Number from— | | | | | |
|---|---|---|---|---|---|---|---|
| | | Western hemisphere | Europe | Africa | Near, Middle, and Far East | Pacific area | Other |
| 1948–49 | 25,464 | 11,070 | [1] 4,065 | 888 | 8,218 | [2] 845 | 378 |
| 1949–50 | 26,433 | 10,444 | [1] 5,574 | 904 | 8,313 | [2] 938 | 260 |
| 1950–51 | 29,813 | 10,962 | [1] 7,157 | 1,027 | 9,411 | [2] 1,110 | 146 |
| 1951–52 | 30,474 | 11,034 | [1] 7,220 | 1,072 | 9,737 | [2] 1,227 | 184 |
| 1952–53 | 33,675 | 12,258 | 7,856 | 1,081 | [2] 11,547 | 316 | [1] 617 |
| 1953–54 | 33,833 | 13,297 | 6,171 | 1,163 | [2] 12,766 | 354 | [1] 82 |
| 1954–55 | 34,232 | 13,160 | 5,196 | 1,234 | [2] 14,254 | 337 | [1] 51 |
| 1955–56 | 36,494 | 13,516 | 5,502 | 1,231 | [2] 15,864 | 353 | [1] 28 |
| 1956–57 | 40,666 | 14,554 | 5,996 | 1,424 | [2] 18,192 | 424 | [1] 76 |
| 1957–58 | 43,391 | 14,566 | 6,816 | 1,515 | [2] 19,901 | 495 | [1] 98 |
| 1958–59 | 47,245 | 15,761 | 6,601 | 1,735 | [2] 22,442 | 612 | [1] 94 |
| 1959–60 | 48,486 | 15,189 | 6,362 | 1,959 | [2] 24,285 | 568 | [1] 123 |
| 1960–61 | 53,107 | 15,754 | 6,686 | 2,831 | [2] 27,084 | 658 | [1] 94 |
| 1961–62 | 58,086 | 16,554 | 6,833 | 3,930 | [2] 29,845 | 796 | [1] 128 |

[1] Includes students from USSR. [2] Includes students from the Philippines.




Total number of foreign students in U.S. institutions of higher education, and number from the East, academic years 1948–49 to 1961–62

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